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Scientific Research Activities at the St. Andrews Biological Station

B. D. Chang, Editor

Biological Station
St. Andrews, N. B. E0G 2X0

February 1990

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SCIENTIFIC RESEARCH ACTIVITIES AT THE ST. ANDREWS BIOLOGICAL STATION

edited by

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ABSTRACT

Chang, B.D. (editor) 1990. Scientific research activities at the St. Andrews Biological Station. Can. MS Rep. Fish. Aquat. Sci. 2054: v + 47 p.

This report presents a brief summary of research activities at the St. Andrews Biological Station from 1987 to 1989. In addition, the report includes a staff list, a list of publications by Biological Station staff in 1987 and 1988, and lists of seminars and workshops held at the Biological Station from 1987 to 1989.

RÉSUMÉ

Chang, B.D. (editor) 1990. Scientific research activities at the St. Andrews Biological Station. Can. MS Rep. Fish. Aquat. Sci. 2054: v + 47 p.

Ce rapport présente un bref sommaire des activités de recherches scientifiques à la Station de biologie de St. Andrews entre les années 1987 et 1989. En plus, le rapport contient une liste des employés, une liste des publications par les employés de la Station de biologie en 1987 et 1988, et listes des colloques et ateliers présentés à la Station de biologie entre les années 1987 et 1989.

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Fig. 1. Aerial view of the St. Andrews Biological Station in 1989.

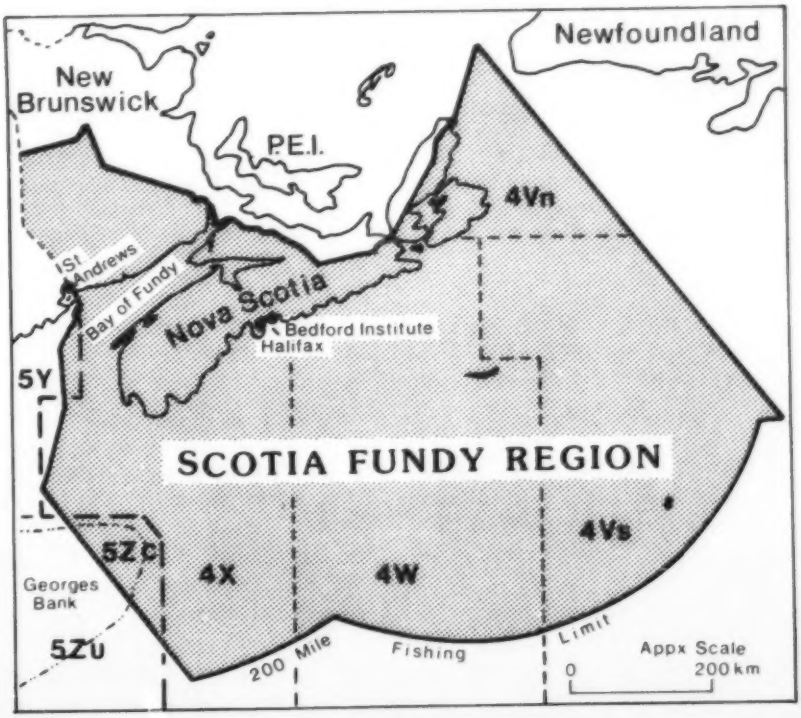

Fig. 2. Map of the Scotia-Fundy Region of the Department of Fisheries and Oceans (DFO), showing NAFO Statistical Areas. DFO's scientific research activities are located at four main locations: the Bedford Institute of Oceanography (Dartmouth), the Halifax Fisheries Research Laboratory (Halifax), the Hollis Building (Halifax), and the Biological Station (St. Andrews).

FOREWARD

The objective of this report is to provide an overview of the various scientific research projects undertaken at the St. Andrews Biological Station from 1987 to 1989. The report serves as an update of *Activity Report of the St. Andrews Biological Station (1986)*[1] and *St. Andrews Biological Station Publications 1977-86*[2].

The St. Andrews Biological Station (Fig. 1), is located on a 9.3 hectare site at Brandy Cove, at the mouth of the St. Croix River, near the town of St. Andrews in southwestern New Brunswick. The Biological Station, Canada's first fisheries research institution, traces its history back to 1898, when a floating laboratory was moored at this site. The first permanent buildings were constructed in 1908.

The Biological Station is an integrated research institute of the Department of Fisheries and Oceans (DFO), within the Science Sector of the Scotia-Fundy Region (Fig. 2). A major reorganization of the Fisheries Research Branch in the Scotia-Fundy Region became effective in April 1987. As a result, the biological science activities at the Biological Station became part of a new Biological Sciences Branch, the marine chemistry and toxicology research programs became part of a new Physical and Chemical Sciences Branch, and responsibility for facilities management was transferred to the Management Services Branch.

At the Biological Station, the Biological Sciences Branch is represented by two Divisions. The Aquaculture and Invertebrate Fisheries Division is headquartered and entirely located at the Biological Station; the Division Chief, Dr. R.H. Cook, also serves as the Director of the Biological Station. The Marine Fish Division, which is headquartered at the Bedford Institute of Oceanography in Dartmouth, Nova Scotia, has two sections located at the Biological Station: the Gulf of Maine Section and the Pelagic Fisheries Section. The Physical and Chemical Sciences Branch, which is headquartered at the Bedford Institute of Oceanography, is represented at the Biological Station by the Toxicology and Organic Contaminants Section of the Marine Chemistry Division.

The research programs of the Biological Station are supported by the Scientific Support Services group of the Biological Sciences Branch, plus staff representing the Management Services, Comptroller's, and Personnel Branches. These units form an integral part of the total resources required to achieve research goals at the Station.

In addition to cooperating with other fisheries research centres in the Scotia-Fundy Region and the rest of Canada, the Biological Station maintains strong ties with many Federal and Provincial agencies. International cooperation is exercised through such agencies as the International Council for the Exploration of the Sea (ICES) and the Northwest Atlantic Fisheries Organization (NAFO).

The Biological Station is a founding member of the Huntsman Marine Science Centre (HMSC), a multiuniversity organization dedicated to marine research and education, located adjacent to the Biological Station. The Atlantic Reference Centre (ARC), housed at the Biological Station, is a collaborative program with HMSC. The ARC provides identification services for aquatic biota, as well as curation and the development of a major reference, research, and teaching collection of aquatic organisms. Other cooperative research projects of the Biological Station include the Atlantic Salmon Demonstration and Development Farm (with the New Brunswick Salmon Growers' Association and the New Brunswick Department of Fisheries and Aquaculture) and the Salmon Genetics Research Program (with the Atlantic Salmon Federation).

The St. Andrews Biological Station, in over 80 years of marine research, has made major contribution to the fisheries sciences. Located in the midst of a highly productive marine ecosystem, in proximity to the major commer-

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[1] Sander, F. 1987. Activity Report of the St. Andrews Biological Station (1986). Can. MS Rep. Fish. Aquat. Sci. 1948: iii + 9 p.

[2] Sander, F. 1988. St. Andrews Biological Station Publications 1977-86. Can. MS Rep. Fish. Aquat. Sci. 1960: iv + 32 p.

cial fisheries of the Bay of Fundy and the Gulf of Maine, as well as to the rapidly developing aquaculture industry, the Biological Station is poised to carry out and expand its scientific research programs in support of Maritimes fisheries, fish habitat, and aquaculture.

Fig. 3. Director's office staff: (l.-r.) B.D. Chang, R.H. Cook (Director), M.T. Parker.

AQUACULTURE AND INVERTEBRATE FISHERIES DIVISION (BIOLOGICAL SCIENCES BRANCH)

Introduction

The Aquaculture and Invertebrate Fisheries Division was created as a result of a reorganization of the Biological Sciences Branch in 1988, when the responsibility for research on invertebrate fisheries in the Bay of Fundy area was added to the Fish Aquaculture and Applied Physiology Division. The latter had been formed in the Regional reorganization of 1987 from the Fisheries and Environmental Sciences Division, following the transfer of the marine chemistry components to the Marine Chemistry Division of the Physical and Chemical Sciences Branch and the research programs at the Halifax Fisheries Research Laboratory to the Benthic Fisheries and Aquaculture Division. The Division Chief, Dr. R.H. Cook, also serves as Station Director.

The Division conducts research on the culture of salmonids, marine fish, and marine invertebrates, the effects of aquaculture on the aquatic environment, the effects of algal blooms on fisheries and aquaculture operations, and the effects of acid rain on fish physiology and freshwater ecosystems. The Division is the Department of Fisheries and Oceans' main point of contact with the aquaculture industry in southwestern New Brunswick. The Division also provides management advice and conducts research on the invertebrate fisheries in the Bay of Fundy area, including lobsters, scallops, and clams.

The Aquaculture and Invertebrate Fisheries Division scientific programs are divided into three sections: Aquaculture, Applied Ecology, and Invertebrate Fisheries. The Division also supports the Atlantic Salmon Demonstration and Development Farm, the Salmon Genetics Research Program, and the Atlantic Reference Centre (see *Cooperative Research Projects*, p. 25).

Aquaculture Section

Section Head: R.L. Saunders.

The Aquaculture Section conducts research on salmonid aquaculture (primarily on Atlantic salmon, *Salmo salar*), including growth, smolting, genetics, grow-out technology, and technology transfer, and on marine finfish aquaculture and ecophysiology.

Fig. 4. Aquaculture Section staff: (l.-r.) K.G. Howes, J. Duston, J.D.E. Knox, M.W. Stewart, D.J. Martin-Robichaud, R.L. Saunders, K.G. Waiwood, M.-J. Buzeta, P.R. Harmon, R.H. Peterson.

Salmonid Aquaculture: Growth, Smolting, and Sexual Maturation

Project staff: R.L. Saunders (project leader), P.R. Harmon, M.W. Stewart, J. Duston (Post-doctoral Fellow), J.D.E. Knox (Connors Bros.).

The objectives of the research in this program are to provide solutions to biological problems encountered or anticipated in salmonid aquaculture, to improve quality and cost-effectiveness of producing juvenile and older salmon, and to develop technology for the industry. Research emphasis is on environmental manipulation of juvenile growth, smolt development, and sexual maturation. This physiological approach involves long-term hatching-rearing of juveniles in the laboratory and grow-out in seawater, both in the laboratory and in sea-cages.

Experiments over several years involving manipulation of daylength, temperature, and salinity have led to improved understanding of the endocrinological and other physiological aspects of growth, smolting, and sexual maturation (Fig. 5). A series of experiments have demonstrated that photoperiod, a predictable environmental variable in nature, is a "zeitgeber" or time giver, which signals animals through sensory and a series of complex endocrinological responses to alter their physiology seasonally. Appropriate manipulation of photoperiod can stimulate juvenile salmon to grow faster and to undergo smolting earlier and at times other than that in nature. This has resulted in predictability of response to environmental variables and proposed rearing regimes to improve production through increased growth rate, earlier and more effective smolting, and delayed maturation. Photoperiod and temperature, together with adequate nutrition and husbandry, can be used to increase the production of 1+ smolts, a major objective in the industry.

Ongoing research in cooperation with a major aquaculture company is aimed at developing off-season, as well as underyearling, smolts. Smolt production is expensive, owing to the time required (14-26 months) to grow the fish to smolt size. Application of past and ongoing research results could result in production of smolts in fewer months than in current practice. This program, involving basic research and development of technology, has the potential of greatly increasing efficiency in an industry entering a period of over-production and decreased profits.

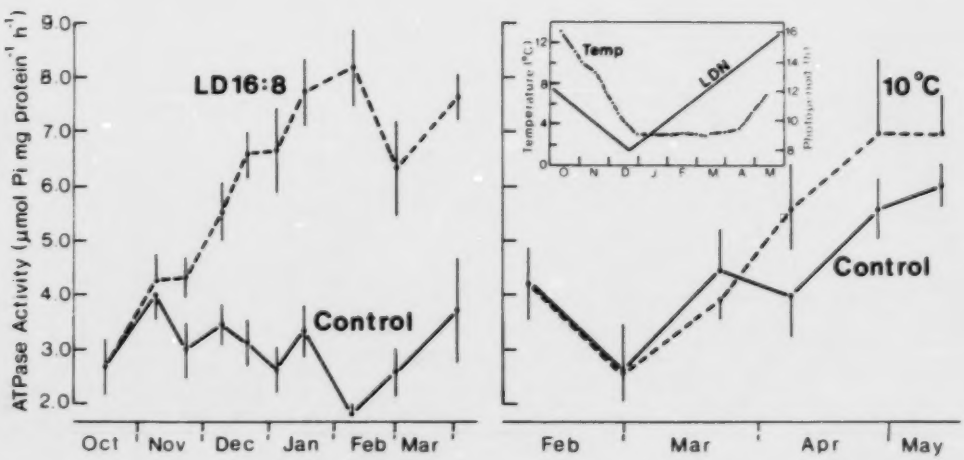

*Fig. 5. The effects of an increase in photoperiod (left) from simulated natural (control) to light:dark 16:8 h and an increase in temperature (right) from ambient (control) to 10°C on gill Na+K+ATPase activity, an enzyme involved in ion transport, in Atlantic salmon (*Salmo salar*) smolts. Inset on right shows control photoperiod (LDN) and control temperature (Temp).*

Effects of Low pH on Salmonid Development

Project staff: R.H. Peterson (project leader).
D.J. Martin-Robichaud.

The projects performed in this program are primarily designed to determine the ways by which low pH affects the early life stages of Atlantic salmon. Processes such as fertilization, water hardening, hatching, embryonic movements, alevin ion exchange, and yolk utilization are investigated at various levels of acidity. Results are interpreted in relation to field studies attempting to delineate the influence of stream pH on survival and production of Atlantic salmon (see *Impacts of Acid Rain on Salmonid Ecology*, p. 7).

This program also includes several field projects. From 1985 to 1989, we have been studying how stream size and associated physical-chemical parameters interact with stream acidity and geographic location to influence stream fish and insect community variables such as species richness. Three stream systems, the St. Croix, Medway, and Gold Rivers, have been studied at a variety of sites encompassing all stream sizes available.

In addition, since 1978, the water chemistry and fish populations of several lakes in southern New Brunswick has been periodically monitored, in cooperation with the Water Quality Branch of the Department of Environment (Moncton). This monitoring program is aimed at determining trends in acidity in these lakes (Fig. 6).

Environmental Requirements for Early Fish Development

Project staff: R.H. Peterson (project leader),
D.J. Martin-Robichaud.

This is a new program, initiated in 1988/89, designed to develop culture methods for the early life stages of fish species which may be potential aquaculture candidates. Aspects to be investigated include design of optimal rearing apparatus for each of the species involved; determination of environmental optima for eggs and fry; study of the early behavior of larvae and fry; and study of the feeding requirements of these early life stages.

Fig. 6. Streams and lakes monitored in Nova Scotia and southern New Brunswick for effects of acidity.

Fig. 7. Investigations on the culture of lumpfish.

Currently facilities are being constructed for the experimental rearing of Atlantic halibut (*Hippoglossus hippoglossus*) eggs and larvae. A striped bass (*Morone saxatilis*) broodstock nucleus has been collected, and some fry have been successfully reared from eggs collected in the wild. Lumpfish (*Cyclopterus lumpus*) have been successfully spawned in the laboratory and feeding of larvae is now under investigation (Fig. 7). Egg and larval rearing chambers for haddock (*Melanogrammus aeglefinus*) are now operational. The early feeding of eel (*Anguilla rostrata*) elvers is being investigated with a view to potential sale of young eels to countries where they are intensively cultured.

The results of this research program will provide some basic knowledge of the early life stages of these species, and provide a source of expertise for their culture, should this become profitable on a commercial basis.

Marine Fish Aquaculture

Project staff: K.G. Waiwood (project leader), M.-I. Buzeta, K.G. Howes.

This program was initiated in 1987 and has three components: broodstock development, juvenile production, and ongrowing studies. To date, efforts have focused on halibut (*Hippoglossus hippoglossus*). About 25 broodstock have been collected and there has been some initial success with natural spawning in a large tidal tank. This has involved the development of technologies for the capture, holding, and transport of fish from offshore areas (Fig. 8). A large broodstock holding facility has also been constructed.

Egg and larval studies will be initiated in 1990 and will complement those conducted by R.H. Peterson and D.J. Martin-Robichaud (see *Environmental Requirements for Early Fish Development*, p. 5). These studies will involve the development of collection techniques for natural zooplankton used to feed larval fish and the design and testing of incubators.

Ongrowing studies were initiated in 1988. The purpose of these studies was to determine survival and growth of juvenile wild-caught halibut in the Passamaquoddy Bay environment. A modified herring weir was used as the grow-out enclosure. Initial results suggest that halibut are quite hardy and exhibit adequate, although not overly impressive, growth. This experiment has been continued in 1989/90.

Other species of interest include haddock (*Melanogrammus aeglefinus*) and cod (*Gadus morhua*).

Fig. 8. Halibut is being investigated as a potential aquaculture species.

Applied Ecology Section

Section Head: D.J. Wildish.

The Applied Ecology Section is studying the effects of aquaculture on the marine environment, the ecology of toxin-producing microalgae and their effects on fisheries and aquaculture operations, and the effects of acid rain on fish (particularly salmon) and freshwater ecosystems.

Fig. 9. Applied Ecology Section staff: (l.-r.) G.L. Lacroix, M.M. Le Gresley, E.P. McCurdy, M.M. Ringuette, D.J. Wildish, J.L. Martin, A.J. Wilson. Absent: A.M. Saulnier, C.A. James.

Aquaculture Ecology Research

Project staff: D.J. Wildish (project leader), J.L. Martin, A.J. Wilson, A.M. Saulnier, M.M. Le Gresley, C.A. James.

This program has two objectives: to devise efficient techniques to determine the extent and biological implications of habitat changes caused by the development of mariculture, including the effect of nutrient enrichment on stimulating red-tide blooms; and to understand the physical environmental and biological factors influencing the production of commercially valuable bivalve mollusc species. This group, formed in April 1987, derives from the phytoplankton and benthic ecology groups of the former Fisheries and Environmental Sciences Division.

Very little is known about possible negative environmental effects caused by the developing salmonid culture industry, either locally or elsewhere in the world. Projects were initiated in 1986-87 to begin this work, including one project to see whether the nutrients released by microbial breakdown of waste food and fish faeces could trigger a red-tide bloom.

A number of monitoring stations have been set up in the Western Isles region to collect hydrographic data, phytoplankton, and sediment samples (Fig. 10). In collaboration with chemical and physical oceanographers from the Bedford Institute of Oceanography, it should be possible to predict the "holding capacity" of salmon farms, as far as nutrient or oxygen levels are concerned.

Recent findings in experimental bivalve feeding ecology will allow a much improved predictive capability regarding how a given area will perform as a bivalve culture site. The experimental techniques developed for this work are being used to test bivalve feeding responses to potentially toxic microalgae, which have recently become a serious problem throughout the bivalve and finfish mariculture industries. The methods show the rates at which toxic microalgae can be ingested, in comparison with non-toxic species of microalgae.

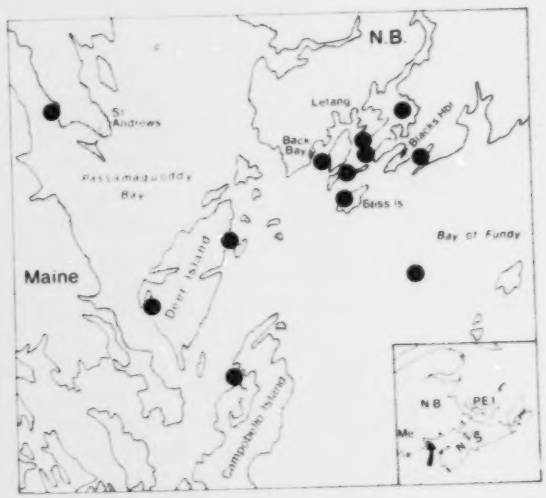

Fig. 10. Phytoplankton monitoring stations in the Western Isles region during 1989.

Impacts of Acid Rain on Salmonid Ecology

Project staff: G.L. Lacroix (project leader), E.P. McCurdy.

This program focuses on the effects of acidification of freshwater on Atlantic salmon and other fish and on their habitat in rivers of

Atlantic Canada. Specific objectives are to determine the ecological and physiological responses of these fish to toxic factors in acidified rivers and to changes in water chemistry over time. Studies are also aimed at identifying the toxic factors of importance in the brown, humic waters that characterize the majority of salmon rivers presently affected by acidic deposition in the southwest region of Nova Scotia.

Atlantic salmon and other fish populations are evaluated in streams representing a range of acidic conditions and over the long-term to depict trends, describe fish community structure, document changes in salmon population dynamics and production, and assist in developing models for predicting the loss of salmon in relation to acidification in rivers of the region (Fig. 11). Any recovery of the resource and its habitat as a result of decreased acid deposition will also be documented. The potential for recovery in chronically acidic streams, the processes of recovery, and the responses of fish to habitat improvement, either through mitigation by liming or by decreased deposition, are also investigated. Research into the toxicological mechanisms involved in acidification and its effect on fish is pursued through exposure experiments in acidified rivers and detailed physiological measurements.

Ecological responses of Atlantic salmon in acidic rivers of Nova Scotia reveal that acid stress directly affects juvenile salmon survival and density. Reproductive success does not extend beyond early life stages if the pH ranges below 4.7. Production falls beyond the lower limit for maintenance of a population if minimum pH levels of 4.7 are reached, and stays well below carrying capacity at pH levels below 5.6. Only at pH levels of 5.6 or more is salmon production similar to that in circumneutral rivers.

Physiological responses of juvenile salmon in acidic rivers indicate that below a threshold of pH 5.0, juvenile salmon experience a substantial impairment in regulation of some plasma electrolytes through effects at the gills. At levels below pH 4.7, there is a complete loss of regulation, leading to death. The responses are related to the direct effects of low pH on gills and not to those of other factors, such as aluminum which is leached in freshwater during acidification. Protection against aluminum apparently comes from the humic substances found in the brown water. Low pH is, therefore, considered to be the main lethal factor directly affecting survival and, as a result, production of juvenile salmon.

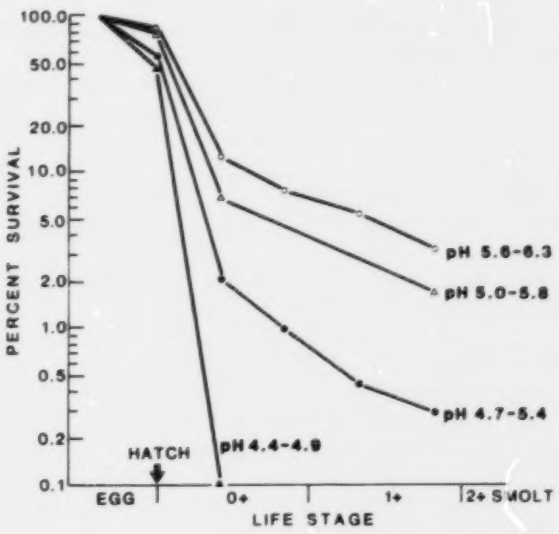

Fig. 11. Survival model for juvenile salmon in acidic rivers.

Invertebrate Fisheries Section

Section Head: D.E. Aiken.

The Invertebrate Fisheries Section conducts resource surveys and provides management advice on the traditional marine invertebrate fisheries of the Bay of Fundy area, particularly lobsters, scallops, and clams, and performs research on the biology, culture, reproductive physiology, and resource assessment techniques for these species. New exploratory invertebrate fisheries are also monitored and evaluated.

Fig. 12. Invertebrate Section staff: (front l.-r.) C.Y. Couturier, G.J. Parsons, D.E. Aiken, P. Lawton, S.L. Waddy; (back l.-r.) J.D. Martin, W.W. Young-Lai, S.M.C. Robinson, J.D.A. Robichaud, R.A. Chandler. Absent: C.A. James.

Invertebrate Biology

Project staff: S.L. Waddy (project leader), D.E. Aiken, W.W. Young-Lai, C.Y. Couturier, C.A. James.

This program produces information on growth, reproduction, and behavior in the American lobster (*Homarus americanus*) and other commercially important invertebrates in support of fisheries management, culture, and the storage and shipment industry.

The program began 15 years ago and has concentrated on life history studies and the development of technology for long-term holding. The effects of the environment on larvae, juveniles, and adults have been revealed and the beneficial effects of low temperature on survival of impounded lobsters have been determined. Thousands of lobsters have been grown from egg to market size and rearing strategies for the many life phases have been developed. The environmental parameters regulating molting, growth, and spawning have been identified and it is now possible to control and regulate such aspects as growth (Fig. 13) and development rates, size at maturity, time of spawning, egg attachment and incubation success, time of egg hatching, and mating. As a result of the long-term studies in this program, maturation and reproduction are better understood in the American lobster than in any other commercial marine species.

Current projects focus on lobster biology in Bay of Fundy stocks. The two areas with the weakest knowledge base in the Fundy fishery are reproduction and early life history and these are currently being studied in both the laboratory and the field. Despite the fact that considerable effort has gone into studying reproduction, there is still little known about when and where it occurs in the Bay of Fundy. Size at maturity of female lobsters from deep waters off Grand Manan was reassessed during the spring and summer of 1989 and it was found to be quite different from that reported in the literature. To strengthen our knowledge in this area, a reproductive profile of Bay of Fundy lobsters will be developed over the next few years. It will include size at maturity, time and frequency of molting, spawning, and larval release for several locations in the Bay. Size at maturity is controlled primarily by temperature and subtle differences in size at maturity indicate differences in temperature regime during the juvenile phase. Size at maturity may therefore provide evidence on the origin of the recruits to this fishery.

Early life history studies are focusing on growth rates under temperature conditions in

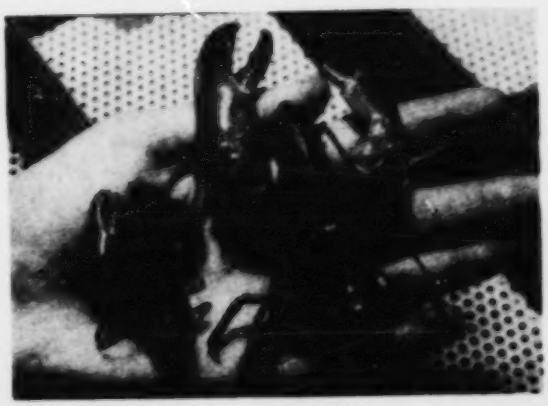

Fig. 13. Variation in growth rates between sibling lobsters.

the Bay of Fundy, so that an accurate determination of age at recruitment can be made.

Effort is also being directed at life history studies of periwinkles, giant scallops, and other commercially important invertebrates.

This program is also involved in the transfer of scientific and technical aquaculture information to the private sector and the general public through the compilation, editing, and publishing of World Aquaculture magazine and the Bulletin of the Aquaculture Association of Canada, including the proceedings of the annual meeting of the Aquaculture Association of Canada.

Lobster Stock Assessment

Project staff: P. Lawton (project leader), J.D.A. Robichaud.

The Crustacean Group is responsible for assessing lobster stocks in three Lobster Fishing Areas (LFAs) within the Bay of Fundy (Fig. 14): LFA 35 (Upper Bay and Nova Scotian shore); LFA 36 (New Brunswick shore) and LFA 38 (Grand Manan). In each LFA, at-sea sampling of catches aboard commercial vessels is undertaken shortly after the fall season opens (in October or November, as opening dates vary between LFAs), and once again in late spring (June or July), shortly before season closure. Earlier monitoring of lobster fishing activities throughout each season has indicated maximal lobster catch rates during the above periods. Figure 14 indicates ports within the Bay of Fundy near which at-sea samples have been taken.

Measurements on lobster characteristics (size, sex, molt stage, and condition of eggs present on females) are taken at sea, along with details of the trap sample (trap type, location, and depth fished). These data are used in conjunction with information on landings (by port and date landed) to generate statistics on the performance of the fishery. This statistical data, along with accumulated information on lobster biology, is used in generating biological advice for input into the fishery management process.

Lobster Research: Juvenile and Adult Field Studies

Project staff: P. Lawton (project leader), J.D.A. Robichaud, J.D. Martin.

Following staff changes and reassignments during 1987-88, a new field-based research program is under development which focuses on recruitment processes in the Bay of Fundy lobster population.

Previous tagging experiments indicate that mature Bay of Fundy lobsters undertake long distance movements into deeper waters to overwinter. A recent hypothesis advanced to explain such migrations is that lobsters attempt to maximize degree-days for growth and egg development. In the case of Grand Manan lobsters this may be accomplished by relatively short movements into the Grand Manan Basin. For lobsters residing in the upper reaches of the Bay, rather longer movements would be required to maintain a preferred thermal regime through the winter. Commencing in April 1989, exploratory trawl surveys are being conducted in the deeper waters of the Central Bay of Fundy to examine the overwintering habits of lobsters. Tagging experiments are planned for spring 1990 to follow subsequent shoreward movement patterns. Further tracking of the movement patterns of adult (and in particular berried female) lobsters is required for definition of lobster stock structure in the Bay, and for the delineation of lobster spawning areas.

Juvenile distribution and centres of lobster production in the Bay are suggested by available fishery sampling, but have not been proven by systematic benthic sampling. Sampling techniques developed in earlier field studies in southwest Nova Scotia are being used in a new project which will investigate juvenile lobster distribution, initially in southwest New Brunswick and Grand Manan. Juvenile lobsters are hand-captured by SCUBA divers or caught in specially constructed lobster traps (which have smaller entrance rings than commercial traps). Ultimate goals of this research program are the identification of factors limiting lobster nursery area productivity, and the development of an index of prerecruit abundance. The field research

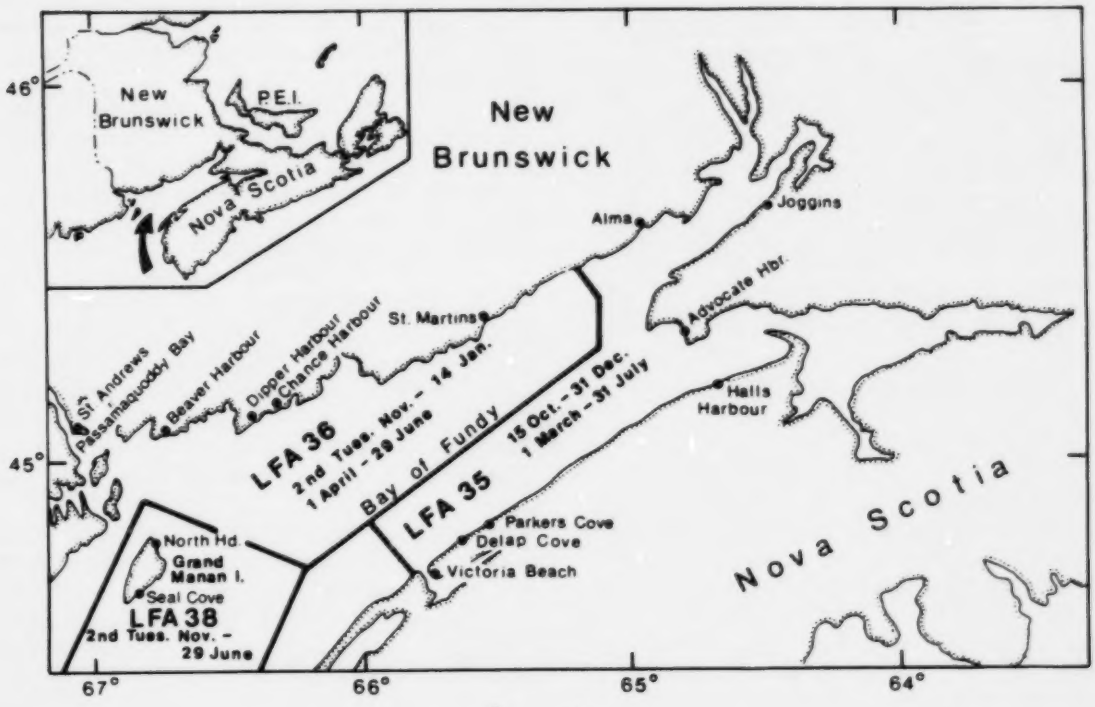

Fig. 14. Lobster Fishing Areas (LFAs) in the Bay of Fundy.

being conducted by the Crustacean Group will likely have significant application in the resolution of conflicts between the lobster fishery, other traditional capture fisheries, and the burgeoning aquaculture industry in the Bay of Fundy.

Soft-shell Clam Ecology and Fishery Research

Project staff: S.M.C. Robinson (project leader), R.A. Chandler, J.D. Martin.

Research on the soft-shell clam (*Mya arenaria*) stocks in the Bay of Fundy region is a new program initiated in the fall of 1988. The objective of the program is to obtain pertinent biological baseline information on the clam populations in the Scotia-Fundy region in order to make informed decisions with regard to pending management measures on the industry. Very little work has been done on soft-shell clams in the Bay of Fundy area since the early 1960s.

A five-year clam enhancement project was initiated in 1988, which involves representation from the Invertebrate Fisheries Section at St. Andrews, the Habitat Ecology Division at the Bedford Institute of Oceanography, the DFO Inspection Branch, Dalhousie University, and the local clam industry.

Detailed information on catch rates, fishing effort, total and harvested population size structure, harvest efficiency, and fishing practices is being gathered in the principal fishing areas as a method of assessing the state of the stocks and determining distribution characteristics. In addition, certain pilot projects designed to enhance existing clam stocks and involving local clam diggers' associations are being evaluated.

Fig. 15. Fishery mortality studies of the soft-shell clam.

Another experiment has been designed to test the current assumptions regarding the degree of mortality caused by use of the clam hack in harvesting soft-shell clams in different areas of the Scotia-Fundy region during different times of the year (Fig. 15). Results from this study will have direct implications affecting the yield calculations from a harvested clam flat. Other ongoing studies deal with the linkage between seasonal reproductive patterns in the clam, environmental cues, and the relative condition of the spawning adults. Biochemical indices are being developed for soft-shell clams in order to give highly accurate short-term measures of physiological condition.

Scallop Population Dynamics and Fishery Research

Project staff: S.M.C. Robinson (project leader), R.A. Chandler, J.D. Martin, G.J. Parsons.

The objectives of this program are to annually assess sea scallop (*Placopecten magellanicus*) populations in the Scotia-Fundy region (with the exception of the Digby area) and to investigate the population dynamics of scallops in order to understand population fluctuations for prediction of recruitment patterns.

The assessment mandate for Grand Manan, Passamaquoddy Bay, Fundy Isles, and the upper Bay of Fundy is a new one for the Biological Station, having recently been transferred from Halifax. Assessment work presently involves the use of 4-gang Digby drags using lined and unlined bags on cruises to survey the local scallop stocks (Fig. 16). Studies include the evaluation of the relative fishing performance of different types of gear modifications, as well as the testing of some current assumptions on catch selectivity.

One project involves research on the early life history stages of the sea scallop. It centres on the relationship between scallop spat distribution and settlement, in conjunction with variables such as bottom type, wind and tidal mixing of the water column, water circulation patterns, and proximity of adult spawning stocks. Information resulting from this study may provide clues to recruitment processes at work in the area, as well as spat collection techniques for research or aquaculture purposes.

An active program on reproductive aspects of sea scallops in the Passamaquoddy Bay area has been ongoing since the 1960s and a large data base has been developed. A study is presently under way to examine long-term seasonal trends in the reproductive patterns over an 11 year period and compare the results with scallop stocks in other locations in the Maritimes.

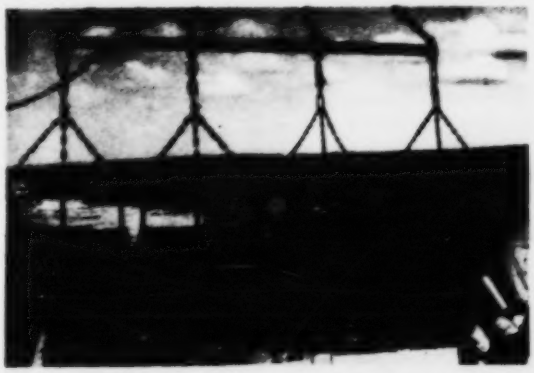

Fig. 16. A 4-gang Digby scallop drag.

MARINE FISH DIVISION (BIOLOGICAL SCIENCES BRANCH)

Introduction

The Marine Fish Division of the Biological Sciences Branch is responsible for studying the biology and production processes of groundfish, pelagic fish, and marine mammals on the Scotian Shelf, in the Bay of Fundy, and on Georges Bank. This includes determining the sizes of important commercial populations and studying environmental, biological, and human factors influential on these resources. Department of Fisheries and Oceans managers, the fishing industry, and the general public are provided with information and advice on the impact of their activities and the optimal use of these valuable populations.

Fig. 17. Staff of the Marine Fish Division at the St. Andrews Biological Station: (l.-r.) U. Buerkle, J.J. Hunt, R.L. Stephenson, R.J. Perry, L.L. Brown, T.D. Iles, C.A. Dickson, R.J. Losier, M.J. Power, I.I. Thompson, H.M. Sampson, D.J. Gordon, C.D. Burnett, J.D. Neilson, C.W. Nelson, M.B. Strong, J.D. Trynor, J.B. Sochasky, R.K. Robichaud. Absent: S. Gavaris, J.M. Porter, P.D. Perley, W.H. Dougherty.

The Marine Fish Division is geographically split between two sites: one at the St. Andrews Biological Station and the other at the Bedford Institute of Oceanography (BIO). The office of the Division Chief, R.N. O'Boyle, is at BIO.

The St. Andrews component comprises two sections: the Gulf of Maine Section, which is responsible for assessments and research on groundfish populations in the Gulf of Maine area; and the Pelagic Fisheries Section, whose mandate is assessments and research on herring in the entire Scotia-Fundy Region and on large pelagic fish populations. In addition to these two sections, Dr. T.D. Iles, in the capacity of Senior Scientist, conducts studies on pelagic fisheries management.

The BIO component (not covered in this document) comprises four sections and is responsible for research on the dynamics of the groundfish populations on the Scotian Shelf, as well as the marine mammal populations throughout the Region.

Gulf of Maine Section

Section Head: S. Gavaris.

The Gulf of Maine Section is responsible for assessments and research on groundfish populations in the Gulf of Maine area, including Georges Bank and the Bay of Fundy. The main stocks for which management advice is provided are haddock and cod on Georges Bank. This requires close collaboration with international fisheries scientists and organizations, particularly those in the United States. Scotian Shelf flatfish (particularly halibut) are also in this Section's mandate. Studies of the oceanographic processes influencing the distribution and abundance of fish populations are conducted in this Section. Research on juvenile gadoids and the development of prerecruit surveys has been another recent research focus. This Section is responsible for conducting standard groundfish abundance surveys and age determinations for the Division's assessment requirements. It also provides Divisional hydrographic service.

Haddock Assessments and Associated Research in the Georges Bank-Gulf of Maine Area

Project Staff: S. Gavaris (project leader), C.W. Nelson.

Research is being conducted on the population biology of the haddock (*Melanogrammus aeglefinus*) inhabiting the waters of Georges Bank. This information is used to assist in the management of the Canadian fishery. Due to the transboundary distribution of the resource, joint work with American colleagues from Woods Hole is a key part of the program.

The haddock fishery on Georges Bank is one of the oldest on the east coast. Previous work has assumed that one population inhabited the entire Georges Bank area. A reexamination of this work, along with new information, suggests that a number of stocks inhabit this area. The one of interest to Canada is associated with the northeast peak of Georges Bank. Valuable research data on the age/size composition of the landings are available as far back as 1931. Also. the research survey time series starts in 1963. This information is currently being processed to more clearly define the distribution of abundance, by age groups, across the Canada/U.S.A. border.

Analysis of the spawning and growth potential of the population is also continuing. Haddock from the area are known for their large size. A study is planned to evaluate if this is due to environment or genetics. This work is essential to determining the long-term growth potential of the resource.

Cod Assessments and Associated Research in the Georges Bank-Gulf of Maine Area

Project Staff: J.J. Hunt.

The fishery for cod (*Gadus morhua*) on Georges Bank has been important to the regional economy since the 1800s and research on the factors influencing the distribution and abundance of the resource is fundamental to effective management.

As with haddock, recent work by the group has shown that a cod stock can be defined by the northeast peak area of Georges Bank. Interestingly, there appears to be more mixing of these fish with those on Browns Bank to the north than with the stock to the south. The research, which is based on the examination of tagging work, commercial sampling, and survey results, is being finalized for publication in the scientific literature.

Monitoring the abundance of this stock is a central mandate of the group. Thus, the historical data for the northeast peak is being reanalyzed to allow description of long-term trends. New programs are also being initiated. A groundfish survey on Georges Bank was initiated in 1986. This, along with existing American surveys, will be an essential component of the assessment of this resource.

The activities of the commercial fishing fleets are also being studied. In the summer of 1989, consultations with industry groups in southwestern Nova Scotia were undertaken to establish joint science-industry programs in the population biology of this and other groundfish resources in the area.

Flatfish Assessments and Associated Research

Project Staff: J.D. Neilson (project leader), P.D. Perley.

A number of flatfish populations reside in the Scotian Shelf-Gulf of Maine area. These include yellowtail flounder (*Limanda ferruginea*), witch flounder (*Glyptocephalus cynoglossus*), American plaice (*Hippoglossoides platessoides*), winter flounder (*Pseudopleuronectes americanus*), and Atlantic halibut (*Hippoglossus hippoglossus*). For the first four species, stock identification has always been a subject of debate. For the last few years, research has been underway using available research such as tagging, spawn distribution, and surveys to more clearly define stock boundaries. It is now apparent that plaice in NAFO Division 4VW are a separate stock. This work will continue for the near future.

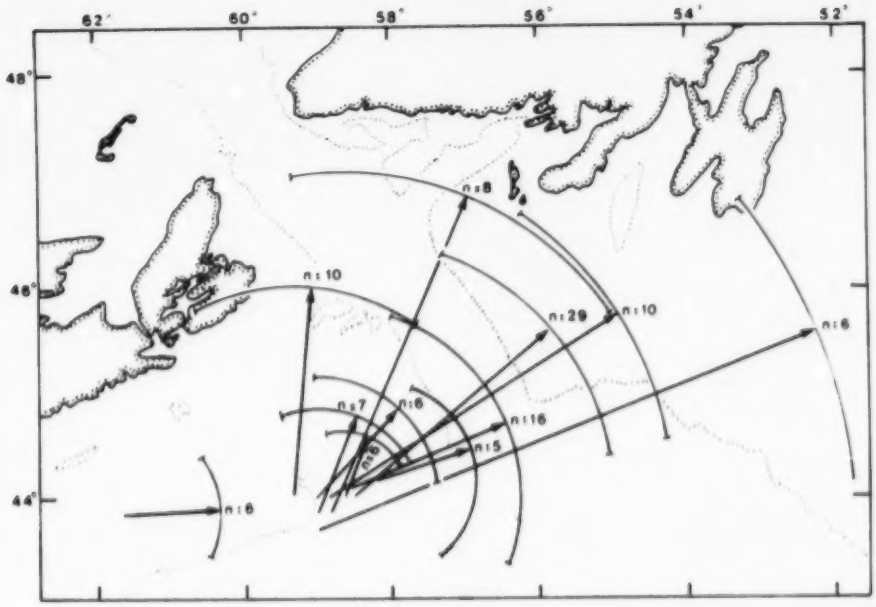

Fig. 18. Mean direction of movement of tagged Atlantic halibut released on the Scotian Shelf. Arrow length indicates mean distance, and the arc drawn at the head of each is the angular dispersion.

The economic importance of halibut has required the initiation of an extensive research program on this species. The first step of this study is the identification of spawning grounds. A two-year study with the Maritime Fishermen's Union has yielded extensive new information which shows that halibut spawn in the deep water off the Scotian Shelf during the fall months. The distribution of the individuals once they are recruited to the population is being studied through surveys (Fig. 18) and examination of commercial statistics.

As with all fisheries, the management of flatfish stocks is always a contentious issue. The team has been active in examining the optimal harvesting strategy for halibut and the impacts of various regulatory tools on the long-term viability of the resource. This includes documentation of the survivability of small halibut caught by trawl, and the impact of a minimum size regulation.

Groundfish Fisheries Management Studies

Project Staff: S. Gavaris.

Since 1977, Canada and the U.S.A. have pursued different management objectives and regulatory methods for their groundfish (cod, haddock, and pollock) fisheries. In Canada, the focus is on the protection of stock growth potential, while in the U.S.A., prevention of recruitment overfishing is the main feature of the system. It is unclear how different or, indeed, how similar the two systems actually are. A study is being conducted to evaluate the equivalency of the two systems. This addresses the objectives of the two systems, the definitions of management units and stock boundaries, the strategies to attain stated objectives, and the regulatory methods to control harvesting. The analysis makes extensive use of computer simulation and allows examination of the impacts of the two

separate management systems on each other's harvesting of a shared resource. The work will serve as a valuable starting point in future discussions with American fishing interests.

Groundfish Trawl Surveys

Project Staff: S. Gavaris (project leader), R.I. Perry, I.I. Thompson, L.L. Brown.

Groundfish trawl surveys have been a key element of both assessment and research-related activities in the Marine Fish Division since the 1950s. A standard series of cruises was initiated in 1970 and is currently the main indicator of stock size trends for most of the region's groundfish. At the moment, surveys are run every summer on the Scotian Shelf and every spring on Georges Bank. These require significant preparation and organization. First, cruise plans and activities are scheduled well ahead of time. At-sea procedures are documented and staff are trained to conduct the required tasks. Methods to improve quality control of trawl behavior through the use of remote sensing devices (i.e. SCANMAR) are presently under study. The samples and data that return to St. Andrews at the end of the cruise require a significant amount of processing. Over the last two years, the historical data sets have been reprocessed to uncover any errors that might have slipped through the system. All these data are stored on computer data banks where software allows easy and ready access. In the coming years, efforts will be made to move at-sea data recording to more automated, computer-intense activities.

Groundfish Age Determination

Project Staff: J.J. Hunt (project leader), C.W. Nelson, R.K. Robicheau, H.M. Sampson, M.B. Strong.

The determination of a fish's age is one of the major elements of the age-structured approach to stock assessment used by the Marine Fish Division. This team is tasked with the processing of ageing material called otoliths (fish ear bones) for groundfish species collected through the port and observer sampling programs (Fig. 19). Annually, about 30 000 otoliths are read (10 000 for cod *Gadus morhua*, 8 000 for haddock *Melanogrammus aeglefinus*, 6 000 for pollock *Pollachius virens*, 3 000 for plaice *Hippoglossoides platessoides* and 3 000 for silver hake *Merluccius bilinearis*) and the data entered onto the Division's data bases. With so many otoliths being collected, it is important to identify which otoliths are essential to be aged. Prioritization schemes are being investigated to guide this sub-sampling exercise. Quality control involves inter- and intra-reader comparisons as well as participation in national and international workshops on otolith reading methodology. Recently, otolith exchange programs were pursued with the U.S.S.R. (silver hake) and one is planned with the U.S.A. (cod, haddock, pollock).

Otolith reading training for staff outside the group is being enhanced to spread this valuable expertise throughout the Division's staff and to ensure a minimum level of redundancy.

An important step in age reading is the preparation of the otolith for reading. Research by the group has shown that the margin of reading error can be high by inappropriate alignment of the otolith in the optical field. Procedures have been established to ensure correct otolith interpretation.

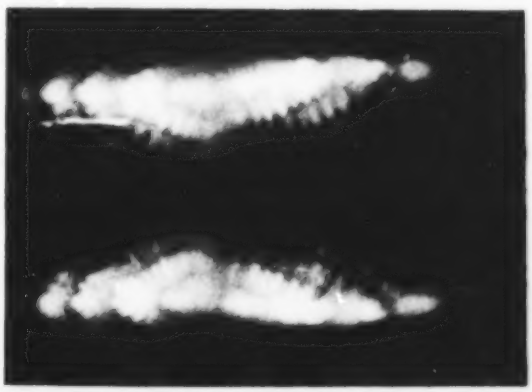

Fig. 19. Silver hake otoliths (age 4).

Groundfish Distribution and Community Studies

Project Staff: J.S. Scott.

Groundfish have long been known to distribute themselves according to their physical environment. Quantification of the effects of the environment can greatly reduce the variability observed in survey data, as well as enhance our understanding of the processes affecting commercial catch rates. This information is valuable when one is interpreting survey and commercial catch rates as indices of stock abundance.

During the past few years, documentation of the effects of the environment on groundfish distribution was undertaken and completed. Strong seasonal and age-related effects were observed.

Dr. Scott retired in 1989 after a long, productive career. His work on distribution and environment is being continued by other members of the Division, both at BIO (S. Smith) and St. Andrews (I. Perry).

Parasitology of Groundfish

Project Staff: J.S. Scott.

Parasites are naturally occurring pests of most groundfish. Due to population dispersion processes, particular species and abundance levels tend to be related to particular stocks. For this reason, the incidence of parasites can be used as a biological indicator of stock discrimination.

Studies on Atlantic halibut helminths and digenean parasites have proved invaluable in the determination of the stock status of these species.

Dr. Scott retired in 1989. A parasitologist for many years, his lasting contributions will provide the basis for future work in this area.

Juvenile Fish Ecology and Surveys

Project Staff: J.D. Neilson (project leader), R.I. Perry, P.D. Perley.

Recruitment of juvenile fish to the fish resources is the main cause of long-term variability in catch levels and is thus the subject of much research, both here and around the globe. This research unit is examining exactly when year-classes are formed and what factors influence this development process.

Thus far, laboratory work by the group has shown that traditional measures of the nutritional well-being or condition of early life stages of gadids are unreliable; this finding has necessitated the investigation of alternative techniques. The present and future direction of the group includes developing techniques for elemental analyses of otoliths of marine fish to allow inferences concerning stock structure and life history transitions.

Field studies (Fig.20) have included descriptions of the diets of juvenile cod, haddock and silver hake, and determination of the interactions between a caligid ectoparasite and juvenile gadids on Georges Bank. Investigations of diel vertical migrations of gadids on Georges Bank have led to the realization that patterns of distribution differ, even at closely-adjacent sites, and are apparently related to local variations in hydrography. This work has been extended to other species in a major review, and challenges the notion that diel vertical migration is an obligate process for many marine fish species. Recent submersible-based observations in cooperation with colleagues in the U.S.A. have led to the hypothesis that survival of juvenile cod on Georges Bank may be related to whether they settle on a large gravel lag deposit on the northeast peak.

This work has required the development of new survey designs, gear and processing procedures and will be useful in the establishment of juvenile surveys for the purposes of stock recruitment.

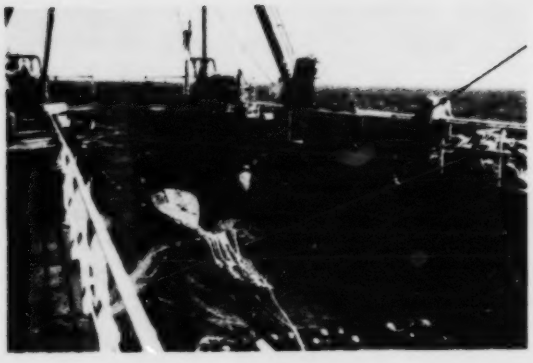

Fig. 20. Retrieving the International Young Gadid Midwater Trawl, the principal gear employed during studies of juvenile fish.

Oceanography and Fish Distribution

Project Staff: R.I. Perry (project leader), R.J. Losier.

The objectives of this program are to understand the effects of physical and biological oceanographic processes on the distribution, migration, and recruitment of commercial fish populations. The region of interest is the Scotian Shelf and Gulf of Maine, including Georges Bank and the Bay of Fundy.

Several projects are currently underway. The effect of year-to-year variations in the timing of the spring phytoplankton bloom on the survival of larval cod and haddock has been examined off southwest Nova Scotia. Such variations in timing of the bloom are due to differences in solar radiation and wind strength between years.

Two projects are examining the associations of young and adult fishes with water masses of specific oceanographic conditions. These projects monitor the temperatures and salinities of these water masses, and identify their associated fish species. This will allow changes in distribution and migration patterns of these fishes to be predicted when temperatures and salinities change. Two areas are presently being studied: the relationship of adult fishes to water masses on the Scotian Shelf; and the relationship of larval and juvenile fishes to tidal fronts (regions of strong changes in temperature and salinity) on Georges Bank. Understanding these associations will improve surveys of fish abundance, leading to better management techniques. Such understanding will also aid in predicting the impact on fish of local and global changes in climate (e.g. see Fig. 21), as might ultimately be caused by the greenhouse effect.

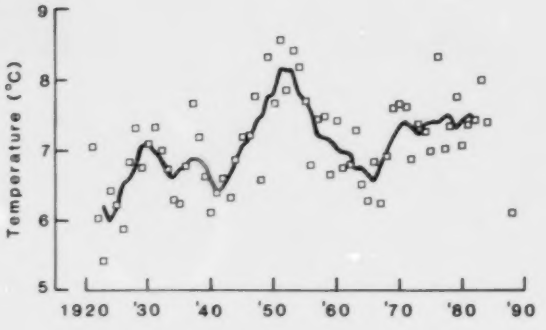

Fig. 21. Long-term changes in sea surface temperature at St. Andrews.

The staff also participates in industry and management meetings, as required, to explain or elaborate on assessments and research findings and to advise on the management strategies used to exploit the resources.

Oceanographic Data Handling

Project Staff: R.I. Perry (project leader), R.J. Losier.

A key element of fish population research is the development of long-term time series of oceanographic data such as water temperature and salinity. The Marine Fish Division has been systematically collecting and processing this information since the 1950s. Current advances in technology have improved the quality and quantity of this information but also demand significant increases in computer processing to keep ahead of this accumulating data. This team, in cooperation with a like

team at BIO, handles the processing of the physical oceanographic information collected by the Division. It is also responsible for integrating this information with other sources to facilitate its association with other data bases such as the fish population surveys.

Pelagic Fisheries Section

Section Head: R.L. Stephenson.

The Pelagic Fisheries Section conducts assessments and research on herring populations in the Scotia-Fundy Region, and on large pelagic fishes (primarily swordfish). The Section contains a research unit dedicated to acoustic estimation of herring populations and research on fisheries acoustics.

Herring Assessments and Associated Research in Subareas 4 and 5

Project Staff: R.L. Stephenson (project leader), C.D. Burnett, W.H. Dougherty, D.J. Gordon, C.F. Monaghan, M.J. Power.

The herring (*Clupea harengus harengus*) fisheries of the Bay of Fundy-Scotian Shelf area are amongst the oldest and most important in eastern Canada. They have played a vital part in fisheries management developments over the last 20 years and, because of the Canada/U.S.A. transboundary nature of some of them, will continue to present biological questions that are of real and current interest to managers at both the national and international level.

Stock assessment of the herring in NAFO Divisions 4Vn (Sydney Bight) and 4WX (Scotian Shelf-Bay of Fundy) are conducted and presented to CAFSAC (Canadian Atlantic Fisheries Scientific Advisory Committee) annually. Research into assessment methodology is undertaken to improve the accuracy and precision of management advice.

Research into aspects of herring biology at the larval, juvenile, and adult stage is conducted in support of the assessment function. Work continues on improving the annual fall survey for larval abundance, which is used as the main indicator of 4WX stock biomass trends. Both the intensity and spatial coverage have been increased to better define the distribution of larvae. In the upcoming year, an extensive analysis of the spring larval survey series will also be undertaken to investigate its worth in determining incoming recruitment to this stock.

Logbooks collected from purse seiners fishing the 4WX resource are routinely compiled and information packages sent out to fishermen. In the near future, this data set will be used to develop fishing behavior and abundance trend models.

Research on the Georges Bank (5Z) resource focuses on monitoring its recovery through fall larval surveys, much like those discussed above. This resource, once the largest on the east coast, declined due to a combination of poor recruitment and overfishing in the late 1970s. Our surveys in 1986 and 1987 indicated a reappearance of herring, which more recent evidence suggests is a resurgence of a remnant of the original population, rather than recolonization from a neighboring group. This is being debated in the scientific

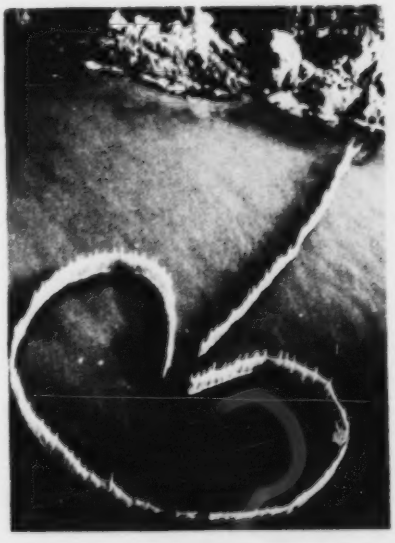

Fig. 22. Aerial view of a herring weir.

literature and will be the focus of more work in the coming year.

A related issue under investigation is the origin of the juvenile herring that supply the weir fisheries in New Brunswick and Nova Scotia (Fig. 22). A stock identification project involving fish biochemistry and body structure is underway to characterize the fish from eight spawning sites, both in Canada and the U.S.A. Joint research with the U.S.A. is important as much of the Canadian weir fishery is thought to be dependent on fish migrating up the Gulf of Maine coast and even from Georges Bank. This work has been expanded to involve the study of weir performance in association with aquaculture (Fig. 23).

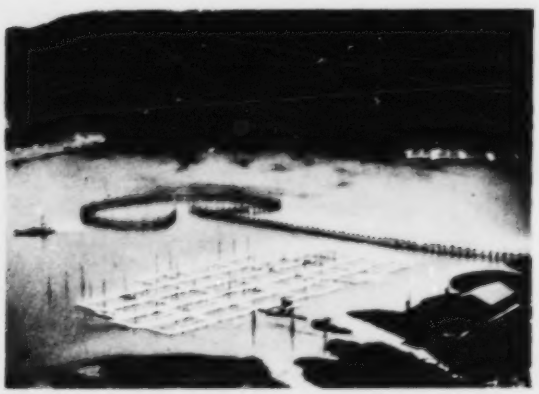

Fig. 23. Salmon aquaculture cages are sometimes located in close proximity to herring weirs.

Pelagic Acoustic Surveys

Project Staff: U. Buerkle (project leader), J.D. Trynor, C.A. Dickson

During the last decade, the technology to acoustically count fish, particularly herring, has advanced to the point where it can be used on a routine basis to provide estimates of fish population size. Comparison of the results to on-going traditional estimates of abundance (i.e. sequential population analysis) is being pursued so as to allow understanding of the factors affecting the acoustic estimate. As well, editing procedures are being defined to correctly process the acoustic data. For instance, during the last year, it was determined that on steeply sloped bottoms, the echoes for fish can be confused with the bottom. Software was developed to rectify this problem.

During 1989, a new survey sampling design was used to estimate total herring stock biomass. The design was a success and will be enhanced in the coming years to cover areas where herring may reside.

Until now, the lab has employed single beam technology. Dual beam equipment (ECOLOG II), which will allow greater resolution of acoustic information, is currently being evaluated. In the near future, training programs on the use of acoustic equipment will be developed, so that all members of the Marine Fish Division scientific community can take advantage of this powerful technology.

Large Pelagics Assessment and Research

Project Staff: J.M. Porter (project leader), C.A. Dickson.

The study of the biology of the large pelagic fishes (swordfish *Xiphias gladius*, tuna *Thunnus* spp., and large sharks) resource in the region is the mandate of this team. After several years of dormancy, this program has been reestablished to meet the increasing needs of active fisheries. The first step in program development has been familiarization with the methods and issues in the fisheries. Contact has been made with industry, as well as scientists in the Gulf Region, the province of Nova Scotia, universities, and the U.S.A., to foster cooperation among those interested. Data have been collected to enhance our participation in the assessment of both swordfish and tuna. Preliminary samples have been collected to investigate stock identification of these species.

During the coming year, the research program will be further developed to investigate age-specific growth in swordfish, methods of

swordfish longline capture and selection, distribution and stock structure of swordfish, and preliminary observations on a shark fishery.

Pelagic Fisheries Management Studies

Project Staff: T.D. Iles (Senior Scientist).

This project reports directly to the Division Chief.

The northwest Atlantic herring fisheries were the first multinational fisheries to come under management control. The evolution of this management system, its current status and its future prospects as a Canadian resource to the north, and as a joint Canadian-U.S.A. resource to the south, are thus worth documenting.

During the coming year, a brief outline and review are planned as a chapter in a larger review for eastern Canada.

Three major aspects of herring biology are being studied: 1) analyses of the accumulated biological data base for the Bay of Fundy-Scotian Shelf area to establish some fundamental concepts underlying both biology and assessment; 2) the so-called "drift-retention" polarity of views on the factors responsible for the distribution and life-history patterns of individual herring stocks; and 3) the erection of a comprehensive herring stock theory to take into account the biological advances of the last quarter century or so.

MARINE CHEMISTRY DIVISION (PHYSICAL AND CHEMICAL SCIENCES BRANCH)

Introduction

The Marine Chemistry Division of the Physical and Chemical Sciences Branch, which is headquartered at the Bedford Institute of Oceanography, has its Toxicology and Organic Contaminants Section located at the St. Andrews Biological Station. Prior to 1987, the marine organic chemistry programs at the Biological Station had been part of the former Fisheries and Environmental Sciences Division.

Toxicology and Organic Contaminants Section

Section Head: V. Zitko.

The Toxicology and Organic Contaminants Section dealt in the past exclusively with the identification of hazards and the estimation of risks of organic chemicals to fisheries. Since the 1987 toxic mussels incident, the Section also became involved in research on marine toxins. In addition, because of its chemical analytical equipment and expertise, the Section cooperates with other programs at the Biological Station on matters requiring analytical chemistry.

Fig. 24. Toxicology and Organic Contaminants Section staff: (l.-r.) H.M. Akagi, J.M. Babineau, V. Zitko, L.E. Burridge, K.G. MacKeigan, K. Haya, B.A. Waiwood. Absent: M.M. Ringuette.

Currently, the section has four projects:

- risk assessment of organic chemicals to fisheries.
- molluscan toxins.
- aquatic toxicology of marine phytotoxins.
- biochemical indicators of health of aquatic organisms.

Risk Assessment of Organic Chemicals to Fisheries

Project staff: V. Zitko (project leader), J.M. Babineau, H.M. Akagi, K.G. MacKeigan.

The objectives of this project are the detection, quantitation, and confirmation of anticipated as well as unanticipated industrial organic chemicals in water, sediment, and biological samples; the identification of hazards and the assessment of risks to fisheries of existing as well as new organic chemicals; techniques of information extraction from analytical and toxicological data; and the development of quantitative structure-activity relationships for toxicity assessment, and of spectral as well as retention time data bases for the identification of chemicals.

Numerous new chemicals are being introduced in commerce. Their hazards must be identified and risks associated with their uses must be assessed. In very general terms, hazard is the mechanism by which chemicals cause harm; for example, direct toxicity resulting in a fish kill. Risk is the likelihood that the harm will occur under given circumstances. Because of the large number of chemicals, it is important to be able to predict with confidence the toxicity and environmental behavior of many of them. This is the purpose of quantitative structure-activity relationships. On the other hand, one must be able to detect and identify chemicals in fish, water, sediments, etc. This requires chemical analytical instruments and tested methods. Finally, modern instruments can acquire large amounts of data and one must be able to summarize and digest the information. This is the field of chemometrics.

Hazard identification and risk assessment were performed on a number of new chemicals, including nonylphenol-type surfactants and some dyes. A screening method was established for 16 pesticides involved in a warehouse fire, and a method for the measurement of nitrotoluenes in biological samples is under development. An organosilicone oil was identified in a sample from a waste disposal site. For information extraction, a display system for polychlorinated biphenyls, dibenzodioxins, and dibenzofurans was developed, and Canadian and published data on emissions and levels of chlorinated dibenzodioxins and dibenzofurans were evaluated by principal component analysis.

Chlorinated dibenzofurans are widely-spread and persistent environmental contaminants. They range from mono- to octachloro-, and include 135 congeners. Those containing chlorines in positions 2,3,7, and 8 are more toxic than the others. The congeners can be presented graphically in coordinates convertible into the chlorine substitution pattern (Fig. 25).

In support of other programs, a method for the detection of the antibiotic oxytetracycline in aquaculture fish is being developed and methods for other antimicrobials will follow. In addition, gases generated by anoxic sediments under aquaculture sites are analyzed by mass spectrometry.

Molluscan Toxins

Project staff: V. Zitko (project leader), J.M. Babineau, H.M. Akagi, K.G. MacKeigan.

The objectives of this project are to detect, quantitate, and confirm the presence of known toxins such as gonyautoxins (paralytic shellfish toxins, PSP), domoic acid, okadaic acid and other diarrhetic shellfish toxins (DSP), tetrodotoxin, and brevetoxins in biological samples, and to isolate, identify, and quantitate other natural compounds in biological samples.

The toxic mussels incident of 1987 underlined the need to have in-house equipment, methods,

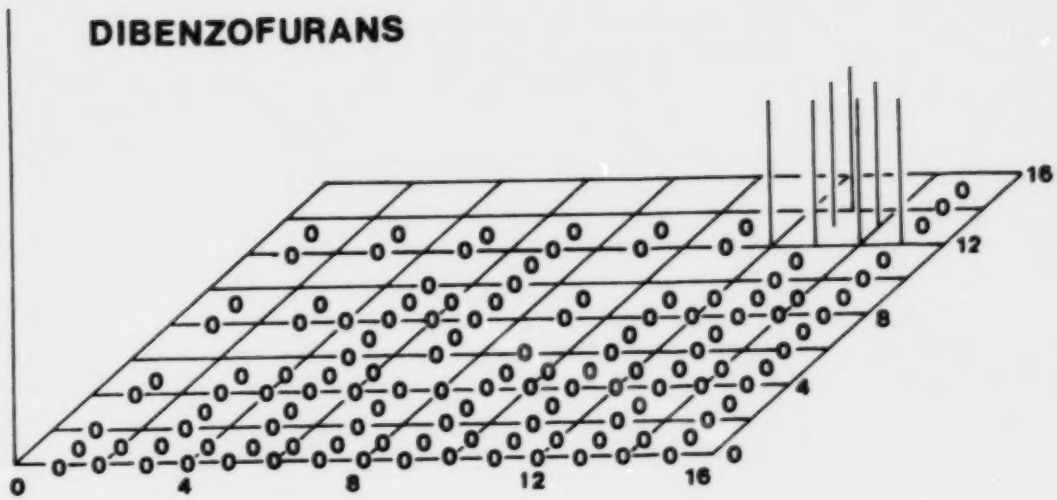

Fig. 25. Positions of all 135 chlorinated dibenzofurans. The toxic "2,3,7,8"-type congeners are indicated by bars. Substitution sites 1 and 6, 2 and 7, 3 and 8, 4 and 9 have values of 1,4,8,2, respectively. To get the X and Y coordinates, add values for ring 1 (1-4), and ring 2, respectively. For example, for 2,3,4,7,8-tetrachlorodibenzofuran the coordinates are X=14 (4+8+2), Y=12 (4+8).

and expertise to detect, identify, and quantitate natural chemicals of high biological activity. During November 1987, an outbreak of a sickness with neurological symptoms occurred and was associated with the consumption of cultured mussels from the Cardigan River, P.E.I. At least 150 cases and three fatalities have since been reported. In the toxic mussels incident, the initial search was made for pesticides, with a special attention to organophosphates, because of the neurotoxic symptoms reported in the victims. Since pesticides and typical ingredients of pesticide formulations were not detectable, and the toxicant was extractable by water, but not by organic solvents, it was concluded that it was a water-soluble natural toxin. Without equipment to speak of for this type of compound, it was determined that it was a low molecular weight toxin, probably containing nitrogen. Shortly afterwards, the toxin was identified by Dr. J. Wright of the Halifax Laboratory of the National Research Council as domoic acid, a neurotoxic amino acid. In cooperative research with the National Institute of Health Laboratories in Washington, D.C., U.S.A., it was shown that domoic acid, in addition to its own neurotoxicity, synergizes other potentially neurotoxic amino acids, normally present in mussels (aspartic and glutamic acid).

In another incident, "toxic" oysters were analyzed for DSP and other potential organic toxicants. No toxicants could be detected and the conclusion was that inorganic components, including chloride, bromide, magnesium, and zinc, were responsible for a positive mouse bioassay.

Equipment received as a result of the toxic mussels incident is being brought on line and methods for the detection of okadaic acid are being implemented.

Aquatic Toxicology of Marine Phytotoxins

Project staff: K. Haya (project leader), L.E. Burridge, B.A. Waiwood, M.M. Ringuette, J.L. Martin (Applied Ecology Section).

Toxins produced by marine phytoplankton can reach undesirable concentrations during annual blooms. Within the Scotia-Fundy Region, paralytic shellfish toxins, domoic acid, and diarrhetic shellfish toxins are of concern. This project is concerned with the impact of toxin-producing phytoplankton blooms on wild and cultured finfish and shellfish industries. The objectives are to identify the lethality of marine phytotoxins to fish, determine the movement of phytotoxins through the food web, develop techniques for the detection and quantification of toxins, and improve prediction and detection of toxic algal blooms and the accumulation of toxins in shellfish.

This project was initiated as a result of our participation in DFO's response to the "toxic mussel crisis" (see *Molluscan Toxins*, p. 22-23).

Concentrations of domoic acid as high as 900 µg/g wet weight were found in homogenates of mussels sampled from the Cardigan River in November 1987. During the summer of 1988, low concentrations of domoic acid (<30 µg/g wet weight) were found in cultured and wild mussels from Passamaquody Bay, New Brunswick. The presence of domoic acid in the mussels and the filtrate from sonicated plankton tows coincided with a bloom of *Nitzschia pseudodelicatissima*.

During July 1988, a small bloom of *Alexandrium fundyense* (7.5 x 10^3 cells/L) occurred in southwest Bay of Fundy. Atlantic mackerel, *Scomber scombrus*, were sampled from 9 locations (Fig. 26). Concentrations of paralytic shellfish poisoning (PSP) toxins of 40 to 209 µg saxitoxin equivalents/100 g wet weight were found in mackerel liver. The PSP toxin profile suggested that mackerel do not accumulate PSP toxins exclusively from *A. fundyense*, and that mackerel may be a vector for the transfer of PSP toxins higher up the marine food web.

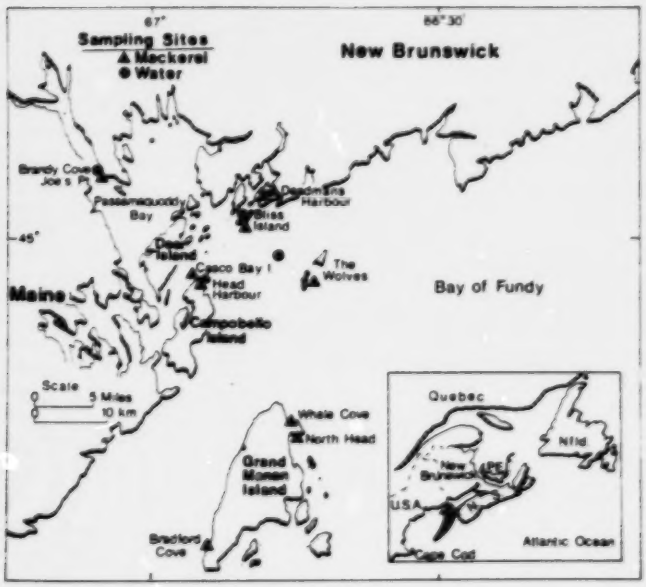

*Fig. 26. Surface water and Atlantic mackerel (*Scomber scombrus*) sampling in southwest Bay of Fundy.*

Biochemical Indicators of Health of Aquatic Organisms

Project staff: K. Haya (project leader), B.A. Waiwood, L.E. Burridge.

Pollution of aquatic systems leading to massive fish kills is readily identified. However, sublethal concentrations of chemicals which lead to chronic conditions of ill-health may result in a small, but continuous, reduction in population. Stresses inflicted on an organism's mechanisms for maintaining a healthy physiological state may cause changes in histological properties and behavioral, physiological, and biochemical processes. The objective of this project is to develop such responses into a series of diagnostic tests and techniques to identify conditions of ill-health in aquatic animals, communities, and populations. The indicators of ill-health will also find application as an early warning signal of impending pollution; in identifying the hazards of chemicals to aquatic animals, particularly those related to fisheries and aquaculture; and in the

development of water quality criteria. More specific indicators may also identify the class of chemicals causing the effect.

Recent studies have been on the effects of sublethal levels of chemicals on the biochemical sequences by which living systems store and utilize energy (intermediary metabolism) and the processes which regulate ion distribution between the animal and water (osmoregulation). Emphasis has been on the relationship between the exposure to pesticides and chemicals used in finfish aquaculture, and starvation, growth, osmoregulation, and intermediary metabolism.

Our studies suggested that there was, in response to the stress caused by exposure to chemicals, an increased utilization of energy. Under controlled laboratory conditions, decreases in stores of energy (glycogen and creatine phosphate) were associated with exposure to pesticides and low pH. For example, juvenile Atlantic salmon (*Salmo salar*) exposed to these chemicals had less muscle and liver glycogen than those not exposed. The effects were greater for those salmon starved during exposure than those fed daily. Creatine phosphate stores were depleted in worms, *Nereis virens*, exposed to organochlorines. Glycogen stores were also found to vary with the degree of physical stress during capture, nutritional status, life stage, and dissolved oxygen concentration. Thus, glycogen stores may be a good indicator of health for fish held under laboratory and aquaculture conditions, but may be of limited use for wild populations. The effects on the key enzyme in osmoregulatory processes, sodium-potassium-activated adenosine triphosphatase, have been variable.

These studies have demonstrated the need for more information on the normal variability of these biochemical indicators and the effects of natural "stressors" (for example, salinity, season, temperature, photoperiod, life stage, water chemistry), before we can identify the biochemical responses that can be implemented as indicators of ill-health in aquatic animals.

COOPERATIVE RESEARCH PROJECTS

Atlantic Salmon Demonstration and Development Farm

The Atlantic Salmon Demonstration and Development Farm (ASDDF), formerly known as the Salmonid Demonstration and Development Farm (SDDF), is a project of the New Brunswick Salmon Growers' Association (NBSGA), in cooperation with the New Brunswick Department of Fisheries and Aquaculture and DFO. The purpose of this project is to facilitate the transfer of salmonid sea-cage culture technology to the developing aquaculture industry in the Bay of Fundy. The SDDF was founded in 1985 under the Canada/New Brunswick Fisheries Economic and Regional Development Agreement (ERDA) on Fisheries Development. The establishment of the Farm was organized by the Biological Station, with the administration being the responsibility of Salmonid Seaculture Ltd., at whose site in Lime Kiln Bay (20 km east of the Biological Station) the sea cages were located. In April 1989, the management of the Farm was taken over by the NBSGA and a new marine site was established, about 1 km southeast of the original site. DFO continues to provide financial and scientific support, salmon smolts, shore-based facilities, and equipment. The Chief of the Aquaculture and Invertebrate Fisheries Division, Dr. R.H. Cook, is the Project Authority for DFO and serves on the project's Management Committee. The Manager of the ASDDF is Mr. E.B. Henderson (NBSGA).

The first experiments began in April 1986, in eight cages at the Lime Kiln Bay aquaculture site of Salmonid Seaculture Ltd. By 1987, the farm had 16 cages in operation (Fig. 27). Experiments during 1987 and 1988 examined the effects of cage types (wood, metal, plastic), smolt origin, smolt size, feed type (dry, moist, silage-based), feeding regimes, and smolt density on growth, mortality, and sexual maturation of caged Atlantic salmon. Preliminary results have been reported in a series of Progress Reports, which are provided to salmon growers.

The ASDDF is also involved in collaborative studies examining fish quality, nutrition,

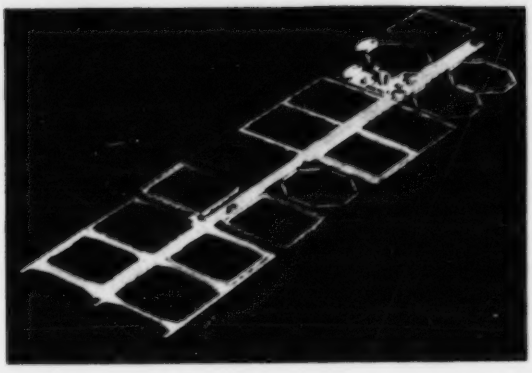

Fig. 27. The Atlantic Salmon Demonstration and Development Farm in Lime Kiln Bay in 1987.

antifouling agents, egg viability of caged salmon, effects of photoperiod on growth and performance, environmental effects of cage operations, scallop culture techniques, and the oceanography of Lime Kiln Bay. The ASDDF also maintains two strains of salmon in cages for the Salmon Genetics Research Program.

Salmon Genetics Research Program

The Salmon Genetics Research Program (SGRP), initiated in 1974, is a cooperative project of DFO and the Atlantic Salmon Federation, located in Chamcook, near St. Andrews (Fig. 28). The original objectives of the program were to determine the genetic and environmental effects on Atlantic salmon growth and development in freshwater, migration to sea, growth at sea, and subsequent return. With the growth of the salmon aquaculture industry, the mandate of the SGRP has been expanded to include growth and maturation of salmon in the sea-cage environment.

Work since 1987 has continued the selection and breeding program according to the requirements of the four selected strains. Smolts released either to sea-cages or to the wild are tagged, so that biological data and individual pedigree can be determined at harvest.

Marine holding of genetic strains is now accommodated in four cages at the Atlantic Salmon Demonstration and Development Farm in Lime Kiln Bay. A genetic analysis has been completed on the growth in sea-cages of all four SGRP strains.

Over 130 of the salmon released to the wild have returned to the Chamcook site in each of 1987, 1988, and 1989, an improvement over previous years. The factors responsible for the low recovery rates of sea-ranched strains have been analyzed. Other areas of research include the effects of photoperiod extension on growth, the production of sterile fish, and the genetic potential for resistance to disease.

With the rapid expansion of the salmon aquaculture industry in the Bay of Fundy, and the importance of broodstock management in support of this new industry, a Working Group was established to review the industry's requirements for broodstock development in southern New Brunswick. It was recommended that the SGRP serve as a primary breeder and that the number of aquaculture strains be increased. In 1989, the New Brunswick Salmon Growers' Association became members of the SGRP and new initiatives are under way to enhance the aquaculture broodstock component of the program.

The SGRP is governed by a Steering Committee, chaired by the Chief of the Aquaculture and

Fig. 28. Aerial view of the Atlantic Salmon Federation research facilities, site of the Salmon Genetics Research Program.

Invertebrate Fisheries Division, and receives advice from a Scientific Advisory Committee consisting of experts in salmon biology and genetics. This group meets annually to ensure that the quality and scientific integrity of the program is maintained. The Chief Scientist of the SGRP is Dr. G.W. Friars (Atlantic Salmon Federation).

Atlantic Reference Centre

The Atlantic Reference Centre (ARC) is a taxonomic service and research activity located at the Biological Station. The ARC is a joint venture of the Biological Station and the Huntsman Marine Science Centre (HMSC). It was formed in 1984 through consolidation of the Biological Station's Identification Centre and HMSC's Ichthyoplankton Laboratory. The Director of the ARC is Dr. K.J. Sulak (HMSC).

The ARC museum maintains over 150 000 lots of preserved aquatic specimens organized into six collections: the Habitat Collection of marine fish eggs and larvae; the Phylogenetic Reference Collection, representing a wide spectrum of organisms including marine and freshwater fishes, marine invertebrates, aquatic insects, fish parasites, and marine algae; the Osteological Collection of fish skeletons; the Fish Otolith Collection; the Fish Photograph and Radiograph Collection; and the Teaching Collection. The ARC collections contain most of the known fauna of the Bay of Fundy, adjacent Scotian Shelf, and the deep sea off Atlantic Canada. The collections are growing by about 10 percent per year.

The ARC has several responsibilities: the management of the taxonomic collection, including curation and maintenance of the specimen collection, operation of an identification and taxonomic service, implementation of an information filing and retrieval system for specimens, and maintenance of specimens from selected DFO survey programs; the provision of professional and scientific advice in marine taxonomy; and the operation of a training service for the identification and preparation of biological specimens for DFO personnel.

SCIENTIFIC AND ADMINISTRATIVE SUPPORT SERVICES

Introduction

The research programs of the Biological Station are supported by the Scientific Support Services group of the Biological Sciences Branch, and on-site staff representing the Management Services, Comptroller's, and Personnel Branches.

The Manager of the Scientific Support Services group also serves as the Coordinator for the Management Services Branch activities at the Biological Station and reports to the Station Director.

Scientific Support Services (Biological Sciences Branch)

Staff:

Manager: W.J. Ross.
Data Processing: A. Sreedharan, S.E. Bellis, G.E. Fawkes, J.R. Gale, S.I. Fawkes, B.H. Hatt.
Word Processing/Secretaries: B.J. Best, M.M. Irwin, M.J. Hurley.
Marine Technology: S.M. Polar.
M/V J.L. HART: W.P. Miner (Captain), G.H. Cline, M.L. Banks, D.E. Haughn.
M/V PANDALUS III: F.S. Guptill (Captain).

The Scientific Support Services group has responsibility for the Station's Computer Centre, the word processing and secretarial staff, the Marine Technology group, and the Station's research vessels.

The Computer Centre provides computing power, programming and system support (both hardware and software), statistical advice, and data entry services to the staff at the Biological Station. The Station's computing needs are served by a VAX 6210, as well as IBM-compatible and Macintosh personal computers (PCs). The VAX 6210 is accessed via PCs and terminals on the LAN (Local Area Network). DATAPAC and PACX facilities permit communications to other Divisions in Halifax and also to other remote locations.

In 1988, the replacement of the HP 3000 by a VAX 6210 was completed. A limited local area network of PCs was put in place to augment the computing capability of scientists and place facilities such as laser printers at their disposal. The HP 250 data entry system was replaced with a PC-based system. For 1989, the primary task will be the migration and conversion of data and programs from the HP 3000 to the VAX 6210, as well as upgrading the communication network to accommodate increasing and diversified demands of the users.

General administrative services, such as typing and secretarial services, are provided for all Station staff. Also, a marine technology service is provided, including electronic and mechanical services.

Fig. 29. Scientific Support Services staff: (front row l.-r.) B.J. Best, S.I. Fawkes, M.M. Irwin, B.H. Hatt, M.J. Hurley; (2nd row l.-r.) G.H. Cline, S.M. Polar, G.E. Fawkes; (3rd row l.-r.) W.J. Ross, J.R. Gale, A. Sreedharan; (back row l.-r.) M.L. Banks, D.E. Haughn, W.P. Miner, F.S. Guptill. Absent: S.E. Bellis.

Research vessels are operated so that the Station's program goals involving resource and stock assessment and associated biological research are furthered in the most effective manner. The Station vessels include the 19.8 metre (65 ft) M/V J.L. HART, the 13.7 metre (45 ft) M/V PANDALUS III, and other smaller boats. The M/V J.L. HART conducts a wide range of work, such as trawling, scalloping, bottom sampling, water sampling, and utilization of specialized gear, from St. Andrews to Georges Bank. The M/V PANDALUS III conducts similar work, primarily as a day boat in the Passamaquoddy Bay area.

Management Services (Management Services Branch)

Staff:

Coordinator: W.J. Ross.
Facilities:
Buildings & Grounds: B.J. Kohler, C.E. Teakles, R.L. Johnson.
Mechanical: D.D. Henderson.
Plumbing: R.A. Carson.
Library: M.J. Rudi, J.E. Cleghorn.
Graphics: P.W.G. McMullon, F.B. Cunningham.
Materiel Management: P.M. Ross, G.F. Wentworth.
Central Registry: M.E Couturier, M.M.B. Bender.

The Facilities section administers approximately 5000 square metres of laboratory and office facilities at the Biological Station. This includes the operation, maintenance and improvements to the physical plant and involves such areas as carpentry, plumbing, heating, electricity, and water supply. During 1988-89, significant projects included the installation of a roof over the tide pool and installation of above-ground oil tanks. Other general improvements were made as required.

The Library section provides library, information, and manuscript editing services to meet the research requirements of a staff of approximately 80 research scientists and technicians at the Biological Station. The library has continued to provide essential library services: acquiring, cataloguing, and classifying new

material; interlibrary loans; and reference services including online searches. The library committee continues to work with the librarian to ensure that library services are responsive to the requirements of the users.

The Management Services group also provides general administration services to meet the scientific and operational requirements of scientists and technicians at the Biological Station. In particular, it provides the following services for all research projects at St. Andrews: materiel management, including purchasing, vehicle management and inventory control; general administrative services; photography and drafting services for publications and demonstrations; and a central registry service.

Fig. 30. Management Services staff: (front l.-r.) M.M.B. Bender, M.E. Couturier, J.E. Cleghorn, M.J. Rudi; (middle l.-r.) B.J. Kohler, D.D. Henderson, F.B. Cunningham; (back l.-r.) P.M. Ross, C.E. Teakles, R.A. Carson. Absent: W.J. Ross, R.L. Johnson, P.W.G. McMullon, G.F. Wentworth.

Regional Personnel Services (Personnel Branch)

Staff: S.A. Anderson, L. Riva.

The Personnel Branch is represented at the Biological Station to provide general personnel services for both the Biological Station and the Area Manager for Southwestern New Brunswick.

Regional Comptroller's Sub-office (Comptroller's Branch)

Staff: D.J. Matthews, E. Dines.

The Regional Comptroller's Sub-office at the Biological Station meets the financial service requirements of all programs at the Biological Station. Up to April 1987, this service was provided only to the Biological Services Branch. This sub-office now also serves the Area Manager for Southwestern New Brunswick, as well as the local scientific programs.

Fig. 31. Regional Personnel Services and Comptroller's Sub-office staffs: (front l.-r.) E. Dines, L. Riva; (back l.-r.) S.A. Anderson, D.J. Matthews.

BIOLOGICAL STATION STAFF 1987-1989

Director's Office

Cook, R.H. *B.Sc.(McGill), M.Sc., Ph.D. (Dalhousie)* Director, St. Andrews Biological Station and Chief, Aquaculture and Invertebrate Fisheries Division

Chang, B.D. *B.Sc., M.Sc. (British Columbia)* Program Biologist (from April 1989)

Parker, M.T. Secretary

Sander, F. *B.Sc. (Sir George Williams), M.Sc., Ph.D. (McGill)* Program Biologist (to October 1987)

Aquaculture and Invertebrate Fisheries Division

Aiken, D.E. *B.A., M.A. (New Hampshire), Ph.D. (Alberta)* Head, Invertebrate Fisheries Section

Buzeta, M.-I. B.Sc. *(Concordia)* Marine Fish Culture Biologist

Campbell, A.W. *B.Sc. (McGill), M.Sc. (Manitoba), Ph.D. (Simon Fraser)* Crustacean Ecologist (to August 1987)

Chandler, R.A. *B.A. (Acadia)* Molluscan Technician

Cook, R.H. *B.Sc. (McGill), M.Sc., Ph.D. (Dalhousie)* Division Chief

Dadswell, M.J. *B.Sc., Ph.D. (Carleton)* Scallop Ecologist (to September 1987)

Graham, D.E. Crustacean Technician (to January 1989)

Harmon, P.R. *B.Sc. (Mt. Allison)* Aquaculture Technician

Henderson, E.B. Aquaculture Technician (to December 1987)

Howes, K.G. *B.Sc. (Guelph)* Fisheries Technician

Lacroix, G.L. *B.Sc. (Waterloo), Ph.D. (New Brunswick)* Ecologist

Lawton, P. *B.Sc. (Bradford, England), Ph.D. (Wales)* Crustacean Ecologist (from January 1989)

Martin-Robichaud, D.J. *B.Sc. (Guelph)* Biologist

Martin, J.D. *B.Sc. (New Brunswick)* Biologist

Martin, J.L. *B.A. (New Brunswick)* Biologist

McCurdy, E.P. *B.Sc., M.Sc. (Acadia)* Biologist

Peterson, R.H. *B.Sc., M.Sc. (New Brunswick), Ph.D. (Carleton)* Physiologist

Robichaud, J.D.A. *B.Sc., M.Sc. (Moncton)* Lobster Biologist

Robinson, S.M.C. *B.Sc. (Acadia), M.Sc. (Simon Fraser), Ph.D. (British Columbia)* Molluscan Ecologist (from September 1988)

Saunders, R.L. *B.Sc. (Massachusetts), M.A., Ph.D. (Toronto)* Head, Aquaculture Section

Stewart, M.W. *B.Sc. (New Brunswick)* Technician (from April 1989)

Waddy, S.L. *B.Sc. (Mt. Allison)* Invertebrate Biologist

Waiwood, K.G. *B.Sc. (Sir George Williams), M.Sc. (Queen's), Ph.D. (Guelph)* Marine Fish Aquaculturist

Widdish, D.J. *B.Sc., Ph.D. (London)* Head, Applied Ecology Section

Williamson, A.M. *B.Sc. (Mt. Allison), B.Ed. (New Brunswick)* Technician

Wilson, A.J. Technician

Young-Lai, W.W. *B.Sc. (Calgary)* Technician

Marine Fish Division

Brown, L.L. Fisheries Technician

Buerkle, U. *B.Sc. (Guelph), M.Sc., Ph.D. (McGill)* Research Scientist, Herring Acoustics

Burnett, C.D. Fisheries Technician (to June 1989)

Dickson, C.A. Senior Biological Technician, Pelagic

Dougherty, W.H. Fisheries Technician

Gavaris, S. *B.Sc. (Memorial)* Head, Gulf of Maine Section

Gordon, D.J. *B.Sc. (McGill), M.Sc. (Guelph)* Fisheries Technician

Hunt, J.J. *B.Sc. (Guelph)* Surveys and Ageing Biologist

Iles, T.D. *B.Sc., D. Sc. (Wales)* Senior Scientist

Losier, R.J. *B.Sc. (Mt. Allison)* Oceanographic Technician

McFarlane, N.J. Biological Technician (to August 1988)

Monaghan, C.F. Port Technician (to September 1989)

Neilson, J.D. *B.Sc. (British Columbia), M.N.R.M. (Manitoba), Ph.D. (Simon Fraser)* Research Scientist, Groundfish

Nelson, C.W. Fisheries Technician
Perley, P.D. *B.Sc. (Acadia)* Fisheries Technician
Perry, R.I. *B.Sc., Ph.D. (British Columbia)* Research Scientist, Oceanography
Porter, J.M. *B.Sc. (Acadia), M.Sc. (Manitoba), Ph.D. (Durham, England)* Research Scientist, Large Pelagic Fish (from April 1989)
Power, M.J. *B.Sc. (Acadia)* Biological Technician
Robicheau, R.K. Senior Ageing Technician
Sampson, H.M. Fisheries Technician
Scott, J.S. *B.Sc., Ph.D. (St. Andrews, Scotland)* Assistant Division Chief, St. Andrews (to June 1989)
Sochasky, J.B. *B.Sc. (Queen's)* Fisheries Technician
Stephenson, R.L. *B.Sc. (Trent), Ph.D. (Canterbury, N.Z.)* Head, Pelagic Fisheries Section
Strong, M.B. *B.Sc. (Mt. Allison)* Sr. Surveys Technician
Thompson, I.I. Fisheries Technician (to October 1989)
Trynor, J.D. Acoustic Assessment Technician

Marine Chemistry Division

Akagi, H.M. *B.Sc. (Dalhousie)* Laboratory Technician
Babineau, J.M. Electronics Technician
Burridge, L.E. *B.Sc. (Dalhousie)* Toxicological Biologist
Haya, K. *B.Sc., Ph.D. (British Columbia)* Toxicologist
Jerome, V.E. *B.Sc. (McMaster)* Chemist (to March 1987)
MacKeigan, K.G. *B.Sc. (New Brunswick)* Chemical Technician (from April 1989)
Ray, S. *B.Sc. (India), Ph.D. (Dalhousie)* Analyst (to February 1988)
Waiwood, B.A. *B.Sc. (St. Andrews, Scotland)* Biochemist
Zitko, V. *Ing. Chem. (Slovak Tech.), C.Sc. (Slovak Acad. Sci.)* Head, Toxicology and Organic Contaminants Section

Scientific and Adminstrative Support Services

Banks, M.L. Engineer/Deckhand (from April 1988)
Bellis, S.E. Computer Supervisor
Bender, M.M.B. General Services Clerk
Best, B.J. Word Processing Supervisor
Carson, A.W. General Serviceman (to August 1987)
Carson, R.A. Laboratory Maintenance Supervisor (from December 1987)
Cleghorn, J.E. Library Clerk
Cline, G.H. Mate (from May 1988)
Cline, R.A. Mate (to September 1987)
Couturier, M.E. Central Registry Supervisor (from June 1988)
Cunningham, F.B. Draftsman
Fawkes, G.E. Progammer/Analyst
Fawkes, S.I. Computer Operator
Foulkes, T.J. Technologist (to August 1987)
Gale, J.R. *B.Sc. (Memorial)* Progammer/Analyst
Garnett, W.C.O. Cook/Deckhand (to June 1989)
Guptill, F.S. Master
Haley, R.M. Secretary (to August 1988)
Harris, S.C. Engineer (to January 1988)
Hatt, B.H. Data Conversion Operator
Haughn, D.E. Cook/Deckhand (from June 1989)
Henderson, D.D. Laboratory Maintenance Supervisor (from April 1987)
Hurley, D.F. Master (to February 1988)
Hurley, M.J. Word Processing Unit Operator
Irwin, M.M. Secretary
Johnson, R.L. General Maintenance (from July 1988)
Kohler, B.J. Maintenance Supervisor (from May 1987)
Lee, H.E. General Maintenance (to October 1987)
Lord, F.G. Mechanic (to October 1987)
McLaughlin, D.M. Registry (to June 1988)
McMullon, P.W.G. Photographer
Miner, W.P. Master (from May 1988)
Polar, S.M. Electronics Technician
Ross, P.M. *B.A. (New Brunswick)* Purchasing Agent
Ross, W.J. *B.Sc. (New Brunswick), M.Sc. (Alberta), M.B.A. (Western Ontario)* Manager, Adminstrative and Support Services

Rudi, M.J. *B.A., M.A., (Western Ontario), M.L.I.S. (McGill)* Librarian (from October 1989)
Small, H.C. Maintenance Supervisor (to October 1987)
Sreedharan, A. *B.Sc. (Kerala, India), M.Sc. (Massachusetts)* Statistician
Taylor, J.E. Clerk (to July 1987)
Teakles, C.E. General Maintenance
Warren, D.C. *B.A. (Mt. Allison), M.L.S. (Dalhousie)* Librarian (to October 1988)
Wentworth, G.F. Storesman (to November 1989)

Regional Comptroller's Sub-office

Dines, E. Accounts Clerk
Matthews, D.J. Financial Officer

Regional Personnel Services

Anderson, S.A. Personnel Generalist
Riva, L. Personnel Assistant

Contract and Other Scientific Staff

Gale, D. Contract Technician, Aquaculture and Invertebrate Fisheries Division (January to March 1989)
James, C.A. Contract Technician, Aquaculture and Invertebrate Fisheries Division
Knox, J.D.E. Biologist, Connors Bros. Ltd. Collaborative research with Aquaculture and Invertebrate Fisheries Division
Le Gresley, M.M. Contract Biologist, Aquaculture and Invertebrate Fisheries Division
Ringuette, M.M. Contract Biologist, Marine Chemistry Division (September 1988 to October 1989); Aquaculture and Invertebrate Fisheries Division (from November 1989)
Saulnier (DeCoste), A.M. Contract Biologist, Aquaculture and Invertebrate Fisheries Division
Van Eeckhaute, L.A. Contract Biologist, Aquaculture and Invertebrate Fisheries Division (to December 1988)

Visiting Researchers

Bjerknes, V. (Norwegian Institute for Water Research, Bergen, Norway) Visiting Scientist with R.L. Saunders, Aquaculture and Invertebrate Fisheries Division (August to December 1989)
Charmantier, G. and M. Charmantier-Daures (Université des Sciences et Techniques du Languedoc, Montpellier, France) Visiting Scientists with D.E. Aiken, Aquaculture and Invertebrate Fisheries Division (July 1987 to July 1988)
Duston, J. Post-doctoral Fellow with R.L. Saunders, Aquaculture and Invertebrate Fisheries Division (from November 1987)
Kügel, B. (University of Munich) Visiting Scientist with R.H. Peterson, Aquaculture and Invertebrate Fisheries Division (May to September 1987)

Graduate Students

Coombs, K.A. M.Sc., University of New Brunswick - with R.H. Peterson, Aquaculture and Invertebrate Fisheries Division (1987-1988)
Couturier, C.Y. Ph.D. candidate, Dalhousie University - with D.E. Aiken, Aquaculture and Invertebrate Fisheries Division.
Parsons, G.J. Ph.D. candidate, University of Guelph - with S.M.C. Robinson, Aquaculture and Invertebrate Fisheries Division.

Summer Students

1987
Bray, S.A.
Connors, S.A.
Despres, D.M.
Elhatton, K.M.
Muzzerall, R.A.M.
Ross, P.A.
Stewart, M.W.
Tremblay, D.E.
Warren-Perry, C.R.

1988
Bray, S.A.
Campbell, C.R.
Despres, D.M.
Maynard, T.L.
Ringuette, M.M.
Saunders, G.M.
Theriault, K.M.
Thorpe, B.E.
Tremblay, D.E.
Wildish, J.A.

1989
Thorpe, B.E.
Wildish, J.A.

PUBLICATIONS BY BIOLOGICAL STATION STAFF 1987 and 1988

1987

Primary Publications

Buerkle, U. 1987. Estimation of fish length from acoustic target strengths. Can. J. Fish. Aquat Sci. 44: 1782-1785.

Campbell, A. and A.B. Stasko. 1987. Movements of lobsters (*Homarus americanus*) tagged in the Bay of Fundy, Canada. Mar. Biol. 92: 393-404.

Chadwick, E.M.P., R.R. Claytor, C.E. Léger, and R.L. Saunders. 1987. Inverse correlation between ovarian development of Atlantic salmon (*Salmo salar*) smolts and sea age. Can. J. Fish. Aquat. Sci. 44: 1320-1325.

Charmantier, G. and D.E. Aiken. 1987. Intermediate larval and postlarval stages of *Homarus americanus* H. Milne Edwards, 1837 (Crustacea Decapoda). J. Crustacean Biol. 7: 525-535.

Charmantier, G. and D.E. Aiken. 1987. Osmotic regulation in late embryos and prelarvae of the American lobster *Homarus americanus* H. Milne Edwards 1837 (Crustacea, Decapoda). J. Exp. Mar. Biol. Ecol. 109: 101-108.

Dadswell, M.J., G.D. Melvin, J. Williams, and D.E. Themelis. 1987. Influence of origin, life history, and chance on the Atlantic coast migration of American shad. Amer. Fish. Soc. Symp. 1: 313-330.

Elner, J.K. and S. Ray. 1987. pH profiles from diatom stratigraphies in sediment cores of selected lakes of New Brunswick and Nova Scotia, Canada. Water Air Soil Pollut. 32: 17-29.

Elner, R.W. and A. Campbell. 1987. Natural diets of lobster *Homarus americanus* from barren ground and macroalgal habitats off southwestern Nova Scotia, Canada. Mar. Ecol. Prog. Ser. 37: 131-140.

Gavaris, S. and S.J. Smith. 1987. The effect of allocation and stratification strategies on the precision of survey abundance estimates for cod in NAFO Subdivision 4Vs and Division 4W. J. Northwest Atl. Fish. Sci. 7: 137-144.

Lacroix, G.L. 1987. Fish community structure in relation to acidity in three Nova Scotia rivers. Can. J. Zool. 65: 2908-2915.

Lacroix, G.L. and D.R. Townsend. 1987. Responses of juvenile Atlantic salmon (*Salmo salar*) to episodic increases in acidity of Nova Scotia rivers. Can. J. Fish. Aquat. Sci. 44: 1475-1484.

Lawton, P. 1987. Diel activity and foraging behavior of juvenile American lobsters, *Homarus americanus*. Can J. Fish. Aquat. Sci. 44: 1195-1205.

Macdonald, J.S. and K.G. Waiwood. 1987. Feeding chronology and daily ration calculations for winter flounder (*Pseudopleuronectes americanus*), American plaice (*Hippoglossoides platessoides*), and ocean pout (*Macrozoarces americanus*) in Passamaquoddy Bay, New Brunswick. Can. J. Zool. 65: 499-503.

Mahon, R. and J.D. Neilson. 1987. Diet changes in Scotian Shelf haddock during the pelagic and demersal phases of the first year of life. Mar. Ecol. Prog. Ser. 37: 123-130.

McCormick, S.D., R.L. Saunders, E.B. Henderson, and P.R. Harmon. 1987. Photoperiod control of parr-smolt transformation in Atlantic salmon (*Salmo salar*): changes in salinity tolerance, gill Na+, K+-ATPase activity, and plasma thyroid hormones. Can. J. Fish. Aquat. Sci. 44: 1462-1468.

Neilson, J.D., R.I. Perry, J.S. Scott, and P. Valerio. 1987. Interactions of caligid ectoparasites and juvenile gadids on Georges Bank. Mar. Ecol. Prog. Ser. 39: 221-232.

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ions as estimated by diffusion potentials. Can. J. Fish. Aquat. Sci. 44: 1635-1639.

Peterson, R.H. and S. Ray. 1987. Organochlorine residues in brook trout and yellow perch from New Brunswick and Nova Scotia (Canada) lakes. Water Pollut. Res. J. Can. 22: 352-364.

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Waiwood, B.A., V. Zitko, K. Haya, L.E. Burridge, and D.W. McLeese. 1987. Uptake and excretion of zinc by several tissues of the lobster (*Homarus americanus*). Environ. Toxicol. Chem. 6: 27-32.

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McCormick, S.D. and R.L. Saunders. 1987. Preparatory physiological adaptations for marine life of salmonids: osmoregulation, growth and metabolism. Am. Fish. Soc. Sympos. 1: 211-229.

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Aiken, D.E. (ed.) 1987. Bull. Aquacult. Assoc. Can. 87-4: 52 p.

Aiken, D.E. and S.L. Waddy. 1987. Molting in crayfish - a review. Can. Tech. Rep. Fish. Aquat. Sci. 1587: iii + 34 p.

Baird, J.W., S.C. Stephenson, and S. Gavaris. 1987. Examination of temporal and spatial variability of length compositions for the 1983 Division 3L cod trap fishery with reference to resulting age composition estimation. CAFSAC Res. Doc. 87/11: 16 p.

Buerkle, U. 1987. Methods and software procedures for processing digital data from acoustic herring surveys. Can. MS Rep. Fish. Aquat. Sci. 1902: iv + 63 p.

Buerkle, U. 1987. Results of the 1986 and 1987 winter acoustic surveys of NAFO Div. 4WX herring stocks. CAFSAC Res. Doc. 87/36: 19 p.

Burnett, C.D., J.S. Beckett, C.A. Dickson, P.C.F. Hurley, and T.D. Iles. 1987. A summary of releases and recaptures in the Canadian large pelagic fish tagging program 1961-1986. Can. Data Rep. Fish. Aquat. Sci. 673: iii + 99 p.

Elner, R.W. and D.A. Robichaud. 1987. Assessment of the 1986 fishery for snow crab, *Chionocetes opilio*, off the Atlantic coast of Cape Breton Island. CAFSAC Res. Doc. 87/86: 35 p.

Gavaris, S. 1987. An evaluation of the effect of minimum fish size on yield per recruit for Georges Bank haddock. CAFSAC Res. Doc. 87/37: 13 p.

Hunt, J.J. 1987. Herring sampling program in the Scotia-Fundy Region, 1975-85. Can. MS Rep. Fish. Aquat. Sci. 1923: iii + 21 p.

Hunt, J.J. 1987. An analysis of inconsistencies in estimates of silver hake catch-at-age. NAFO SCR Doc. 87/51, Serial #N1340.

Hunt, J.J. 1987. Results of the 1986 and 1987 Canada/USSR silver hake otolith exchange. NAFO SCR Doc. 87/52, Serial #N1341.

Hunt, J.J. 1987. Status of the Atlantic cod stock on Georges Bank, NAFO Division 5Z and Subarea 6, in 1986. CAFSAC Res. Doc. 87/94: 53 p.

Multiple authors, including J.D. Neilson (rapporteur). 1987. Report of the Early Life History Working Group. ICES C.M. 1987/L:28.

Neilson, J.D. and P.Perley. 1987. A brief biological update on the 1986 4VWX flatfish fisheries. CAFSAC Res. Doc. 87/69: 15 p.

Neilson, J.D., W.R. Bowering, and A. Fréchet. 1987. Management concerns for Atlantic halibut (*Hippoglossus hippoglossus*) in the Canadian North Atlantic. CAFSAC Res. Doc. 87/73: 22 p.

Perry, R.I. 1987. Introduction. *In* R.I. Perry and K.T. Frank (eds.) Environmental effects on recruitment to Canadian Atlantic fish stocks. Can. Tech. Rep. Fish. Aquat. Sci. 1556: 1-4.

Perry, R.I. and A.T. Frank (eds.). 1987. Environmental effects on recruitment to Canadian Atlantic fish stocks. Can. Tech. Rep. Fish. Aquat. Sci. 1556: iv + 65 p.

Perry, R.I. and R.J. Losier. 1987. Review of selected oceanographic conditions during 1985 in NAFO Division 4VWX. CAFSAC Res. Doc. 87/7: 14 p.

Peterson, R.H. 1987. Influence of water pH on frequency of collection of certain invertebrates during lake and stream surveys in New Brunswick and Nova Scotia. Can. Tech. Rep. Fish. Aquat. Sci. 1523: 7 p.

Peterson, R.H., L. Van Eeckhaute, and S.B. Eddy. 1987. Benthic invertebrates of the West-field River (Nova Scotia, Canada). Can. Tech. Rep. Fish. Aquat. Sci. 1561: iii +12 p.

Peutz, A.V.H.A., S.L. Waddy, D.E. Aiken, and W.W. Young-Lai. 1987. Accelerated growth of juvenile American lobsters induced by unilateral eyestalk ablation. Bull. Aquacult. Assoc. Can. 87-2: 28-29.

Potter, D.C., R.G. Lough, R.I. Perry, and J.D. Neilson. 1987. Comparison of the MOCNESS and IYGPT pelagic samplers for the capture of 0-group cod (*Gadus morhua*) on Georges bank. ICES C.M. 1987/L:37.

Power, M.J. and R.L. Stephenson. 1987. An analysis of logs from the 1986 4X summer purse seine fishery. CAFSAC Res. Doc. 87/77: 21 p.

Ray, S. 1987. Application of trace organic analysis to fisheries environmental research. Can. MS Rep. Fish. Aquat. Sci. 1942: iv +18 p.

Ray, S. and V. Jerome. 1987. Copper, zinc, cadmium and lead in scallops (*Placopecten magellanicus*) from the Maritimes. Can. Tech. Fish. Aquat. Sci. 1519: iii + 29 p.

Robichaud, D.A., A.M. Williamson, and D.E. Graham. 1987. Characteristics of the St. Mary's Bay lobster stock in relation to scallop gear impact. Can. MS Rep. Fish. Aquat. Sci. 1955: iv +17 p.

Sander, F. 1987. Activity report of the St. Andrews Biological Station (1986). Can. MS Rep. Fish. Aquat. Sci. 1948: iii + 9 p.

Saunders, R.L. 1987. Winterkill! The reality of lethal winter sea temperatures in east coast salmon farming. Bull. Aquat. Assoc. Can. 87-1: 36-40.

Saunders, R.L., E.M.P. Chadwick, D.E. Knox, and H.C. Freeman. 1987. Rearing environment modifies age at sexual maturity in Atlantic salmon (*Salmo salar*). p. 313-314. *In* D.R. Idler, L.W. Crim, and J.M. Walsh (eds.) Proc. Third Internat. Sympos. Reprod. Physiol. Fish.

Saunders, R.L., E.B. Henderson, and P.R. Harmon. 1987. Extended daylength during autumn enhances growth of juvenile Atlantic salmon. Bull. Aquacult. Assoc. Can. 87-2: 32-33.

Scott, J.S. 1987. Trawl surveys for juvenile groundfish in the Sable Island area, Nova Scotia, 1981-85. Can. Tech. Rep. Fish. Aquat. Sci. 1532: iii + 16 p.

Scott, J.S. 1987. Matrices of co-occurrences of fish species on the Scotian Shelf and in the Bay of Fundy. Can. Tech. Rep. Fish. Aquat. Sci. 1581: iii + 54 p.

Sinclair, M.M. and T.D. Iles. 1987. Population regulation and speciation in the oceans. ICES C.M. 1987/Mini No. 3: 22 p.

Sinclair, M.M., J.W. Loder, D.Gascon, E.P. Horne, I. Perry, and E.J. Sandeman. 1987. Fisheries needs for physical oceanographic information within the Atlantic Zone. Can. Tech. Rep. Fish. Aquat. Sci. 1568: 166 p.

Stephenson, R.L., D.J. Gordon, and M.J. Power.

1987. Herring of the outer Scotian Shelf and Georges Bank: history of the fisheries, recent developments and management considerations. CAFSAC Res. Doc. 87/76: 23 p.

Stephenson, R.L. and M.J. Power. 1987. The 1986-87 4Vn herring biological update. CAFSAC Res. Doc. 87/74: 13 p.

Stephenson, R.L., M.J. Power, and T.D. Iles. 1987. Assessment of the 1986 4WX herring fishery. CAFSAC Res. Doc. 87/75: 39 p.

Waddy, S.L. (ed.) 1987. Proceedings of the 1987 Annual Meeting of the Aquaculture Association of Canada. Bull. Aquacult. Assoc. Can. 88-2: 103 p.

Waddy, S.L. and D.E. Aiken. 1987. Potential of intermolt mating in broodstock management for lobster culture. Bull. Aquacult. Assoc. Can. 87-2: 30-31.

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Waddy, S.L. and D.E. Aiken. 1987. Interaction of temperature and photoperiod in the regulation of spawning by American lobsters (*Homarus americanus*). Am. Zool. 27: 150A (abstract).

1988

Primary Publications

Aiken, D.E. and S.L. Waddy. 1988. Strategies for maximizing growth of communally reared juvenile American lobsters. World Aquaculture 19(3): 61-63.

Charmantier, G., M. Charmantier-Daures, and D.E. Aiken. 1988. Larval development and metamorphosis of the American lobster *Homarus americanus* (Crustacea, Decapoda): effect of eyestalk ablation and juvenile hormone injection. Gen. Comp. Endocrinol. 70: 319-333.

Charmantier, G., M. Charmantier-Daures, and D.E. Aiken. 1988. Human somatotropin enhances the growth of young American lobsters, *Homarus americanus* (Crustacea, Decapoda). C.R. Acad. Sci. Paris (Ser. III) 308: 21-26.

Charmantier, G., M. Charmantier-Daures, N. Bouaricha, P. Thuet, D.E. Aiken, and J.-P. Trilles. 1988. Ontogeny of osmoregulation and salinity tolerance in two decapod crustaceans: *Homarus americanus* and *Penaeus japonicus*. Biol. Bull. 175: 102-110.

Charmantier-Daures, M., G. Charmantier, J.E. Van Deijnen, F. Van Herp, P. Thuet, J.-P. Trilles, and D.E. Aiken. 1988. Isolement d'un facteur pédonculaire intervenant dans le contrôle neuroendocrine du metabolisme hydrominéral de *Homarus americanus* (Crustacea, Decapoda). Premiers résultats. C.R. Acad. Sci. Paris (Ser. III) 307: 439-444.

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Neilson, J.D., E.M. DeBlois, and P.C.F. Hurley. 1988. Stock structure of Scotian Shelf flatfish as inferred from ichthyoplankton survey data and the distribution of mature females. Can. J. Fish. Aquat. Sci. 45: 1674-1685.

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Stephenson, R.L. and M.J. Power. 1988. Vertical migration in herring larvae: a mechanism for larval retention? Mar. Ecol. Prog. Ser. 50: 3-11.

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Waiwood. K.G. 1988. Interannual variation in growth of southern Gulf of St. Lawrence cod (*Gadus morhua*) in relation to biomass, diet composition, river runoff and temperature. p. 139-160. *In* T. Wyatt and M.G. Larrañeta (eds.) International Symposium on Long Term Changes in Marine Fish Populations. Vigo, Spain.

Waiwood, K.G. 1988. A transportable seawater holding facility for research vessels. Aquacult. Eng. 7: 127-138.

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Sander, F. 1988. St. Andrews Biological Station publications 1977-86. Can. MS Rep. Fish. Aquat. Sci. 1960: iv + 32 p.

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Waddy, S.L., D.E. Aiken, and M.D. Eagles. 1988. Growth of cultured American lobsters and effect of culling on growth rates. Bull. Aquacult. Assoc. Can. 88-4: 66-68.

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Popular and Miscellaneous Publications

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Aiken, D.E. 1988. Asia, an aquaculture giant. World Aquacult. Soc. Newsletter 19(2): 1, 10-12.

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Publishers, Edmonton.

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Aiken, D.E. (ed.) 1988. World Aquacult. Soc. Newsletter 19(2): 16 p.

Aiken, D.E. and S.L. Waddy. 1988. Temperature-photoperiod control of spawning by American lobsters: a facultative regulatory system. J. Shellfish Res. 7: 196 (abstract).

Perry, R.I. et al. 1988. Report of the working group on fisheries oceanography. Unpublished report to Marine Fish Division section heads, Bedford Institute of Oceanography, Dartmouth, N.S. 30 p.

Saunders, R.L. 1988. Salmon science. Atl. Salmon J. 37(4): 32-34.

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Waddy, S.L. and D.E. Aiken. 1988. Intermolt mating and insemination in preovigerous American lobsters. Amer. Zool. 28: 110A (abstract).

SEMINARS AT THE BIOLOGICAL STATION 1987-1989

1987

28 January 1987
Mr. Jay Parsons
Acadia University,
Wolfville, N.S. *and*
Aquatic Industries,
St. Andrews, N.B.
Floating seaweed in Passamaquoddy Bay and associated fauna.

12 February 1987
Mr. Les Burridge
St. Andrews Biological Station
Department of Fisheries and Oceans
Use of a fugacity model to assess risk of pesticides in the aquatic environment.

19 February 1987
Dr. John V. Gartner
Department of Marine Science
University of South Florida
St. Petersburg, Florida, U.S.A.
Investigations of midwater fishes and invertebrates in the Gulf of Mexico.

19 March 1987
Mr. David Robichaud
St. Andrews Biological Station
Department of Fisheries and Oceans
Predatory behavior of cod and skate on snow crab and toad crab.

31 March 1987
Dr. Arnfinn Langeland
Directorate for Wildlife and Freshwater Fish
Tungasletta, Trondheim, Norway
Interactions between zooplankton and fish in Norwegian lakes.

23 April 1987
Mr. Larry Hovey
Westfield, N.B.
Underwater video applications for biology (demonstration videos).

30 April 1987
Dr. John Neilson and Dr. Ian Perry
St. Andrews Biological Station
Department of Fisheries and Oceans
Juvenile gadoid studies on Georges Bank.

12 May 1987
Dr. Ken Sulak
Atlantic Reference Centre
Huntsman Marine Science Centre
St. Andrews, N.B.
A pictorial romp through the world of deep-sea fishes.

21 May 1987
Mr. Ed Bollerwell
Control Data Canada Ltd.
Halifax, N.S.
Cyber 930 Computers.

18 June 1987
Dr. T. Poppe
National Veterinary Institute
Oslo, Norway
Fish health programs in Norway.

18 June 1987
Dr. B. Gjerde
Agricultural University of Norway
Ås, Norway
The Norwegian salmon breeding program.

28 July 1987
Dr. Niall Bromage
Aston University
Birmingham, United Kingdom
Photoperiod, endogenous rhythms, and control of reproduction in salmonids.

29 July 1987
Dr. Nigel Merrett
Institute of Oceanographic Sciences
Wormley, Godalming, Surrey, United Kingdom
Ecology of deep living fishes of Porcupine Sea Bight, Northeast Atlantic.

5 August 1987
Dr. Ole Torrissen
Institute of Marine Research
Matre Aquaculture Station
Matredal, Norway
Pigmentation of salmonid fishes.

13 August 1987
Ms. Karin Pittman and Mr. Helge Botnen
Institute for Fisheries Biology
University of Bergen
Bergen, Norway
Development of aquaculture for cod and halibut in Norway / Larval development of halibut.

4 November 1987
Ms. Susan Waddy
St. Andrews Biological Station
Department of Fisheries and Oceans
Interaction of temperature and photoperiod in the regulation of spawning in American lobster.

10 December 1987
Dr. Geoff Fryer
Freshwater Biological Association
Windermere Laboratory
Cumbria, United Kingdom
Morphology, behavioral ecology, and evolution in the Cladocera (Crustacea).

15 December 1987
Dr. Jennifer Specker
Department of Zoology
University of Rhode Island
Kingston, Rhode Island, U.S.A.
Thyroid function in salmonids and the sea water environment.

1988

8 January 1988
Dr. Jennifer McLeese
Département de physiologie
Université de Montréal
Montréal, Québec
Seasonal changes in intestinal structure and function in winter flounder.

13 January 1988
Dr. Rob Stephenson
St. Andrews Biological Station
Department of Fisheries and Oceans
Vertical migration in herring larvae: is it the mechanism for larval retention?

27 January 1988
Dr. Richard H. Peterson
St. Andrews Biological Station
Department of Fisheries and Oceans
The chorion-perivitelline system: structure and function.

3 February 1988
Dr. J.E. Thorpe
Freshwater Fisheries Laboratory
Dept. of Agriculture and Fisheries for Scotland
Pitlochry, United Kingdom
Aspects of salmonid aquaculture and enhancement.

10 February 1988
Dr. Alan Campbell
St. Andrews Biological Station
Department of Fisheries and Oceans
Australia dreaming: a walkabout by a wide-eyed Canuck.

17 February 1988
Dr. Pierre Pepin
Science Branch
Department of Fisheries and Oceans
St. John's, Nfld.
Predation and starvation of larval fish: a numerical experiment of size- and growth-dependent survival.

7 March 1988
Mr. Barry Smith
Department of Zoology
University of British Columbia
Vancouver, B.C.
Possible impacts of intense fishing for males on the reproduction dynamics of the Dungeness crab.

9 March 1988
Dr. M.J.R. Fasham
Institute of Oceanographic Sciences
Wormley, Godalming, Surrey, United Kingdom
Models for pelagic ecosystems.

30 March 1988
Dr. T. Derrick Iles
St. Andrews Biological Station
Department of Fisheries and Oceans
The demolition of the match-mismatch hypothesis.

6 April 1988
Dr. J.S. Scott
St. Andrews Biological Station
Department of Fisheries and Oceans
Groundfish migrations in the Bay of Fundy area.

13 April 1988
Dr. G. Rowe
Dept. of Oceanography
Texas A & M University
College Station, Texas, U.S.A.
Continental shelf: closed or open ecosystem.

27 April 1988
Dr. Guy Charmantier and Dr. Mireille Charmantier-Daures
Laboratoire du Physiologie des Invertébrés
Université des Sciences et Techniques du Languedoc
Montpellier, France
Osmoregulation in decapod crustaceans: ontogeny; neuroendocrine control.

4 May 1988
Dr. Gerhard Pohle
Atlantic Reference Centre
Huntsman Marine Science Centre
St. Andrews, N.B.
Crustacean grooming: why and how to keep clean.

11 May 1988
Dr. J. Manzi
Marine Resources Institute
South Carolina Wildlife and Marine Resources Department
Charleston, South Carolina, U.S.A.
Recent advances in commercial culture of bivalve molluscs.

12 May 1988
Dr. Y. Shimizu
Dept. of Pharmacognosy and Environmental Health Sciences
University of Rhode Island
Kingston, Rhode Island, U.S.A.
The source of the domoic acid in eastern Prince Edward Island.

2 June 1988
Dr. Terry Haines
U.S. Fish and Wildlife Service
National Fisheries Contaminant Research Center
Field Research Station *and*
Department of Zoology
University of Maine
Orono, Maine, U.S.A.
Gill ultrastructure and bone strength as potential bioindicators of acid stress in fish.

7 June 1988
Dr. Masahiro Takeuchi
Tokyo Metropolitan Research Laboratory of Public Health
Tokyo, Japan
Analytical chemistry of tributyltin oxides.

8 June 1988
Dr. Rosemary Johnson
Royal Ontario Museum *and*
Surgical Research Department
Hospital for Sick Children
Toronto, Ontario
Determinants of feeding specialization in European oystercatchers, Haematopus ostralegus.

7 July 1988
Mr. John Kearney
Research and Policy Advisor
Maritime Fisherman's Union
Yarmouth, N.S.
The development of fisheries social science and its application to southwest Nova Scotia.

8 August 1988
Dr. Chris Metcalfe
Department of Biology
Trent University
Peterborough, Ontario
Chemical contaminants in fish tumours.

19 August 1988
Dr. John Marsh
Department of Geography
Trent University
Peterborough, Ontario
Marine parks in Japan.

27 September 1988
Mr. Dan Campbell
Maine Department of Marine Resources
West Boothbay Harbor, Maine, U.S.A.
Model of larval herring recruitment in coastal marine waters.

13 October 1988
Dr. J. Morgan
Visiting Fellow
Northwest Atlantic Fisheries Centre
Department of Fisheries and Oceans
St. John's, Nfld.
The effect of fenitrothion (a forest use pesticide) on foraging in juvenile Atlantic salmon.

13 October 1988
Dr. L. Godbout
Postdoctoral Fellow
Oak Ridge Research University Programs
Environmental Science Division
Oak Ridge National Laboratory
Oak Ridge, Tennessee, U.S.A.
Empirical approach to brook trout sport fisheries.

17 October 1988
Mr. Edward A. Black
British Columbia Ministry of Agriculture and Fisheries
Victoria, B.C.
The new challenge in phytoplankton problems in mariculture.

25 October 1988
Dr. Jens Christian Holm
Institute of Marine Research
Bergen, Norway
Growth rates of Arctic char under intensive culture.

2 November 1988
Dr. Bob Hawes
Department of Animal Science
University of Maine
Orono, Maine, U.S.A.
The Northeast Aquaculture Center's breeding program for oysters.

10 November 1988
Dr. Peter Lawton
Marine Sciences Research Center
State University at Stoney Brook
Stoney Brook, New York, U.S.A.
Dynamics of crab-bivalve interaction in relation to predator control in mariculture.

1989

8 February 1989
Dr. Julie Porter
Ocean Sciences Centre
Memorial University
St. John's, Newfoundland
Colony growth and recruitment in a long-lived vertebrate, the Black-legged Kittiwake.

9 February 1989
Dr. Chantal Abou-Debs
Temora Scientific Services Ltd.
Halifax, N.S.
Natural feeding of molluscan and crustacean macroplankton larvae.

5 April 1989
Mr. Bill Hogans
Atlantic Reference Centre
St. Andrews, N.B.
Biology of sea lice, Lepeophtheirus salmonis *and* Caligus elongatus *(Copepoda: Caligidae) parasitic on cage-cultured salmonids in the lower Bay of Fundy.*

11 April 1989
Dr. Keith Brander
Fisheries Laboratory
Lowestoft, United Kingdom
Recent research on herring larvae in the North Sea.

26 April 1989
Dr. Jim Dustin
Post-doctoral Fellow
St. Andrews Biological Station
Department of Fisheries and Oceans
The role of photoperiod in the control of gonadal maturation and smoltification in salmonids.

18 May 1989
Dr. Ian Perry
St. Andrews Biological Station
Department of Fisheries and Oceans
Possible consequences of CO_2-induced climate variability to northwest Atlantic fish stocks.

19 May 1989
Dr. Bob Gordon
Family pediatrician and diving medical specialist
Bridgewater, N.S.
Hyperbaric medicine: preventing diving emergencies, detecting symptoms of embolisms or decompression sickness, and other diving-related medical topics.

24 May 1989
Dr. Timothy R. Parsons
Department of Oceanography
University of British Columbia
Vancouver, B.C.
The availability of models for determining the effects of climate change and variability on salt water fisheries of British Columbia.

27 July 1989
Dr. J.M. Stewart
Department of Biology
Mount Allison University
Sackville, N.B.
Interaction of fatty acids and cytosolic proteins: fatty acid, binding proteins and myoglobin.

29 August 1989
Dr. Shirley Lim
Department of Zoology
University of Western Ontario
London, Ontario
The Macoma *paradox at Paradox Creek, Hudson Bay.*

20 September 1989
Dr. Gary Gratto
McGill University
Montreal, Quebec
Predator-prey interactions on an intertidal mudflat.

3 October 1989
Dr. Helge Leivestad
Laboratory of Limnology
University of Bergen
Bergen, Norway
Aluminum chemistry and mode of toxic action to fish.

15 November 1989
Dr. Robert H. Findlay
Darling Marine Center
University of Maine
Walpole, Maine, U.S.A.
Temporal variation in microbial processes in a mudflat.

29 November 1989
Mr. Vilhelm Bjerknes
Norwegian Institute for Water Research
Bergen, Norway
Quantifying effluents from Atlantic salmon fish farms and monitoring some of their environmental effects.

WORKSHOPS AND SCIENTIFIC MEETINGS AT THE BIOLOGICAL STATION 1987-1989

1987

14-24 September 1987
Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC) - Groundfish Subcommittee meeting.
Chaired by S. Gavaris (St. Andrews Biological Station).

1988

31 May 1988
Workshop on genetics and breeding relative to Atlantic salmon.
Organized by the Salmon Genetics Research Program, Atlantic Salmon Federation.

12-23 September 1988
Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC) - Groundfish Subcommittee meeting.
Chaired by S. Gavaris (St. Andrews Biological Station).

2-4 November 1988
Third Biennial Benthic Workshop - advective transport and benthic productivity.
Organized by D.J. Wildish (St. Andrews Biological Station), B.T. Hargrave (Bedford Institute of Oceanography), and J. Grant (Department of Oceanography, Dalhousie University).

1989

26 July 1989
Hatchery Management Workshop.
Coordinated by the Salmon Genetics Research Program, Atlantic Salmon Federation.

22 August 1989
Workshop on by-catch of harbor porpoise.
Chaired by M.M. Sinclair (Director, Biological Sciences Branch, Scotia-Fundy Region, DFO).

10-13 September 1989
Canada-Norway Finfish Aquaculture Workshop.
Organized by R.L. Saunders (St. Andrews Biological Station).

2 October 1989
Information exchange with salmonid experts from the U.S.S.R.
Coordinated by the Atlantic Salmon Federation and the St. Andrews Biological Station.

17 October 1989
Salmon Genetics Research Program Workshop.
Organized by the Salmon Genetics Research Program, Atlantic Salmon Federation.

29 January 1988
Various speakers
The poisoned mussel mystery.

31 March 1988
Various speakers
Early life history studies of fish and shellfish at St. Andrews.

30 September 1988
R.L. Saunders
Description of recent visit to Norway and comments on a speech by Frank Oberle, Minister of State for Science and Technology.

15 December 1988
S. Gavaris
Evolution of, and steps followed to develop, a management plan for harvesting groundfish.

16 June 1989
D.J. Wildish
Effects of salmonid mariculture on the environment.

1 September 1989
R.L. Stephenson
Interaction between salmonid mariculture and herring fisheries in the Bay of Fundy.

BIOLOGICAL STATION SCIENCE COUNCIL MEETINGS

The Biological Station Science Council has three objectives: to provide a forum for the discussion and exchange of scientific ideas and information on all scientific activities carried out at the Biological Station; to identify and promote opportunities for cooperative research; and to recommend and, as required, undertake any initiatives that would improve the scientific work environment and/or working relationships at the Biological Station. The formative meeting of the Science Council was held in June 1987. The first Chairperson was Dr. J.S. Scott. Dr. R.L. Saunders assumed the Chair on 30 September 1988.

The Science Council has sponsored a number of "theme sessions":

ACKNOWLEDGEMENTS

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